POTENTIAL IMPACTS OF CULTURAL CHANGE ON THE NAVY IN THE 1970'S

VOLUME 3 PART III

Section 3 TECHNOLOGICAL

Section 4 BIO-MEDICAL

WESTINGHOUSE
DEFENSE & ELECTRONIC
SYSTEMS CENTER

CENTER FOR ADVANCED STUDIES & ANALYSES

1 August 1972

Final Report

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TECHNOLOGICAL

TECHNOLOGICAL

GENERAL

1. As noted in passing, we have already introduced technological aspects of the future on the philosophical and international levels. So pervasive is this activity, however, that here we devote an entire major Section to it, divided into these sub-categories: General, Weapons, Energy, Automation and Computers, Communications, Transportation, and Other aspects.

2. Technology—by which is meant techniques and processes as well as machines for transforming and controlling things and men—pervades every facet of public and private life in industrial society. It is central to the terrible logic of nuclear deterrence, the military tactics in Indochina, the uneasy relations between the industrial and the developing nations, the operations of the Pentagon, and, as Senator Ervin recognizes, the existence of civil liberties. Technology is so integral a part of our economic and political institutions that, as Herbert Marcuse has argued, it is perhaps ideological, for 'not only the application of technology but technology itself is domination (of nature and men)—methodical, scientific, calculated, calculating control. Specific purposes and interests of domination are not foisted upon technology "subsequently" and from the outside; they enter the very construction of the technical apparatus'.

Potential Impact

The Navy is necessarily among the most technologically oriented institutions of society. The great majority of technological advances, from surveillance sattellites in space to automation of personnel records, will impact on the Navy in some way. Advances in metallurgy, propulsion, communications, undersea navigation, nutrition, medical techniques, and numerous other fields have more or less direct applications in the Navy. The overall effect of technological advance is to make structures and procedures more complex (the same effect results from many social and cultural changes also, such as increasing education). The Navy, therefore, can expect to be one of the most heavily challenged of social institutions in the future, in confronting advancing technology and in endeavoring to adapt its many manifestations into a coherent system.

3. The material goods of the future will be many things; but they will not be standardized. We are racing toward "overchoice"—the point at which the advantages of diversity and individualization are canceled by the complexity of the buyer's decision-making process. We may soon reach a point at which the technology can economically produce more diversity than the consumer needs or wants. (BP144)

4. Rescher sees technological advancement as a harbinger of significant changes in social orientation. With the onset of the "Big Brother" state, resulting from the universal data bank, social engineering, and centralized power and control, there will be a probable upgrading of democratic values (in face of obvious threats thereto, demanding greater investment). He also foresees a threat to personal status (dehumanization) as our fate is increasingly in the hands of—not people, but—machines, accompanied by an ambivalent attitude toward authority. Advance of medical techniques, he feels, could result in a weakening of family values (contraceptives), and weakening of value defenses against the unplesant contingencies of human life (diseases rarer; deaths later). (BB16)

Potential Impact

Major innovations in both technological and non-technological spheres of national and international life not only become more complex within themselves but also generate more extensive interactions with other institutions, agencies, and procedures. One general result is to render each organization, however large, less autonomous and self-reliant. Hence, a general trend will be increased interaction between the Navy and other public and private organizations in the United States, and to a lesser extent, internationally.

5. Scientific and technical endeavors in the United States will probably focus on:

-Geometric rate of advancement, especially communication, transportation, nuclear energy, computers, and space.

-Worldwide audio and visual hook-up?

-High-speed large-lift transportation systems.

-Wide use of nuclear energy for power and possibility of fusion for transportation.

-Space vehicles for exploration and other uses.

-Computer technology serving every area of life, including medicine and law.

McHale sees man's increasing ability to change or affect his environment a phenomenon to be addressed at the supernational level. The science of ecology holds important promise as a synthesis of many disciplines, and environmental considerations must enter planning early. Many specialists feel problems can be coped with if addressed in the next decade. A major research effort is needed to identify actions and interactions, as well as widespread recognition of man's capability to alter the world's ecosystems.

Potential Impact

Exclusive of rising manpower costs, the costs of keeping abreast of technological advances will also continue to rise. In the light of widespread opposition to the military-industrial complex and to military budgets in particular, the Navy will be hard pressed to obtain minimum funds to maintain a continually modernized naval establishment, and to allocate available funds judiciously between current operations and research and development seeking future improvements. This increasingly acute dilemma may encourage the Navy to explore additional ways in which to obtain greater support for the Navy among the American citizenry as a whole.

McHale advocates economics analysis to determine the likelihood of government control, the costs of environment protection, and the costs of control measures versus the costs of resource degradation. He foresees satellites for environmental resources management and global weather observation, coupled with development of computer techniques for long-range weather prediction by the 1980's. He predicts sophisticated recycling techniques based on the model of spacecraft life-support systems providing partial solutions to pollution problems, and a limited capability to control or modify weather by 2000. (BM95)

6. A major tool for guiding and controlling technological development is Technology Assessment (TA). Technology Assessment is the systematic study of the possible effects on society when technology is introduced, extended, or modified, with special emphasis on unintended, indirect, and delayed impacts.

A case for the necessity of Technology Assessment is based on the following trends:

(1) Growing complexity of society.

(2) Man's increasing power over nature.

(3) Man's increased ability through scientific knowledge to anticipate the future consequences of his actions.

(4) Large scale of human enterprise.

(5) The "throw-away" society.

Potential Impact

The role played by technological leadership may be imponderable but it is certainly great. The technological relationships between the United States and the rest of the world may well have a good deal to do with whether or not war can be avoided in the future. Technological transfer to countries in lesser stages of technological development will probably continue to be an influential instrument or weapon in American relationships with foreign nations. The Navy will be involved in a number of aspects of such transfer, if they were to be implemented.

Potential Impact

It is not as well known as it should be that there is appreciable fallout from military research that benefits society in general. With the objective of securing wider public appreciation of this form of "technological transfer" the Navy might well consider.

1. Making greater efforts to publicize these social benefits

2. As part of social-action programs, extend Navy participation in selected research and development projects in collaboration with civilian agencies;

(6) Technology's shift to co ɔrn for amenities (esthetics), having satisfied basic utilitarian needs.

(7) Congressional action: e.g., National Environment Policy Act of 1969. (BP146)

7. Implementation of Technology Assessment would have the following effects:

(1) The project may be modified.

(2) Technology will come under continuing surveillance.

(3) Research and development will be stimulated.

(4) Controls will be established.

(5) Technology may be encouraged to move into new areas.

(6) New laws may be required.

(7) Technology may be blocked.

The perspectives of Technology Assessment—advocate's tool, neutral analysis, and search for desirable choices—provide a balanced look at alternatives, options, and possible outcomes.

The Technology Assessment team should be inter-disciplineary. Joint ventures between research institutes and universities may be the best organizations to do TA, pairing broad-based knowledge with systematic management techniques.

certain projects may possess the potential for high-visibility Navy participation.

Potential Impact

In conjunction with the preceding comment, the Navy might consider undertaking certain research and development projects in its own agencies, even without collaboration with civilian agencies, concerning particular projects which are more likely to benefit society as a whole (or even special communities) than the Navy directly.

Potential Impact

Unrelenting technological change will continue the trend of splintering professions and specialties into more numerous sub-professions and subspecialties. This trend will compound the difficulties of forecasting manpower and skill requirements well in advance. Demand for technically trained manpower will remain high, but the spectrum of skills and skill levels associated with specific jobs will be subject to continuous revision. This situation will be especially difficult to cope with in relation to skills which require long lead times to develop and skills which rise or fall in demand with relative suddenness.

There are unsettled issues in the concept of Technology Assessment:

(1) Importance of independence from preconceptions and interests of the sponsor.

(2) Involvement of professionals and their societies.

(3) Assessment of public-interest groups.

(4) Disclosure of dangers, as well as benefits. (BP146)

8. Bauer, in a retrospective Technology Assessment, sees the automobile as an example of ramifying consequences. Following development of the first automobile came the auto-industry, highway systems, and the oil industry as primary impacts. The secondary impacts, more difficult to foresee, included changes in urbanization, patterns of home ownership, retail distribution, suburbanization, domestic injury and mortality, decline of railroads, political patronage (e.g., national highway systems), sexual mores, leisure, health, and other social areas.

Technological Forecasting (TF), another technique for directing technological advancement, is a description or prediction of a foreseeable invention, specific scientific refinement, or likely scientific discovery.

Potential Impact

Relentless technological change will also accentuate the problem of retraining (or otherwise coping with) individuals whose skills become obsolescent.

Potential Impact

The gap between "the two cultures" cited by C. P. Snow, science and the humanities, may become wider, depending upon the scope and pace of change in both technological and social spheres, as well as upon success or failure in incorporating more humanistic considerations in scientific education, and vice versa. The two broad orientations are relatively encapsulated now, and may become more so, during the future when greater inter-disciplinary interaction and understanding will be required. This will present problems to the Navy, not only concerning the generalist vs. the specialist, but also concerning the people-oriented vs. the hardware-oriented sides of the Navy.

Prehoda classes scientific discoveries as probable, possible, and unexpected, and a breakthrough as an unexpected discovery of a new scientific possibility, or a first practical demonstration of a probable development; the timely recognition of breakthroughs allows us to accelerate subsequent progress through increased funding and priorities.

Forecasting technologies are seen as telescoping performance achievements through:

(1) Mathematical modeling

(2) Morphological networks

(3) Scenario

(4) Delphi Method

A synthesis of these methodologies would be best, and results should be widely published in a form which convinces decision-makers of their validity and importance. The final report should be an integrated forecast with a consensual summary of the forecasting team's final conclusions containing:

(1) Long-term state of the art projections.

(2) Identification of key applied research objectives.

(3) Economic and funding projections at alternative research and development levels.

(4) Identification of possible synergistic relationships between technologies.

(5) Presentation of any relatively unknown phenomenon that may offer basic research promise of discoveries and breakthroughs.

(6) Definition of basic research areas where increased support may result in discoveries.

(7) Clarification of "natural barriers" in order to determine whether there are fundamental limitations. (BB276)

9. These points might also apply to social projections. At the stages of forecast, the next stage could be "research economy" in which scientific investigation and related technology development would be the principal sustaining activity of mankind. "Research" is all inclusive.

An understanding of the relationships between automation, unemployment, and research may play the most important role in the effort to maintain our competitive advantage.

Perhaps the central problem lies in organization and accessibility of human knowledge. We must rrain a new class of inter-disciplinary specialists to coordinate, evaluate, and guide scientific effort in the United States. New financial and budgetary patterns must be created to develop the research process at an optimum rate.

A function of the educatic al system is to train a sufficient number of specialists capable of accelerating the rate of fundamental investigation and technology development. The most valuable resource of any nation is the potentiality of its youth.

Many exciting discoveries await basic research in the learning process because so little has been done to date.

In the area of housing, unnecessary stress and incalculable loss of valuable "free" hours of our creative people could be averted by well planned research-center communities of the future which provide work, shopping, and recreational facilities. Man must think of himself as an astronaut living in a self-contained system, wastes must be reclaimed. City planning should incorporate TF and ekistics (the science of human settlements).

On cybernetics, Prehoda says: "I believe that man will never be completely displaced from an important and controlling role in the entire TF loop. Man has the gift of imagination and the spark of interpretive creativity, neither of which is likely to be automated in the foreseeable future."

In any political struggle, freedom is our "secret weapon," an all-important catalyst in bringing about the originality and capacity for innovation necessary for optimum progress in science. Long-range progress depends not so much on the solution of problems already visible as on the appearance of new scientific approaches—on exactly those unforeseen discoveries which a

free society is more likely to uncover through its great diversity in research.

Kahn feels we often underrate the role of synergism and serendipities. It seems a likely conjecture that either the whole nature of international relations will be changed to cope with the technology indicated, or else the system will blow up (large nuclear war); and international relations will be changed, but by a different mechanism and in a different way. (BP224)

10. In education, the implications of wide-spread use of sophisticated teaching machines must be considered:

> These machines can be programmed to teach more than facts; attitudes, abstract ideas, politics and policies can be taught as well. Since the techniques of programming will be controlled by a relatively few people in the country, the exact ideological content of the course of instruction will not be accessible to PTA groups for review and critique. What is taught will be right by definition. Who will program the programmers? (BB16)

11. The education system should plan for surprise. It could well be that the most important area of possible technological change is in the field of social inventions, and these might have the greatest impact on the environment of the educational system. It is not possible to predict what the social inventions will be, but it is possible to suggest challenges. (BB242)

12. As a corollary, Rescher sees the advance of education as possibly resulting in disillusionment with education as such (it will no longer be looked on as the great panacea to all social ills), and in intensification of value stresses due to the gap between educational fitness and "life". (BB16)

13. At this point we present the list prepared by Herman Kahn and Anthony Wiener, containing predictions of one hundred technical innovations very likely in the last third of the twentieth century. (BB170)

1. Multiple applications of lasers and masers for sensing, measuring, communications, cutting, heating, welding, power transmission, illumination, destructive (defensive), and other purposes.

2. Extreme high-strength and/or high-temperature structural materials.

3. New or improved superperformance fabrics (papers, fibers, and plastics).

4. New or improved materials for equipment and appliances (plastics, glasses, alloys, ceramics, intermetallics, and cements).

5. New airborne vehicles (ground-effect machines, VTOL and STOL, superhelicopters, giant and/or supersonic jets).

6. Extensive commercial application of shaped-change explosives.

7. More reliable and longer-range weather forecasting.

8. Intensive and/or extensive expansion of tropical agriculture and forestry.

9. New sources of power for fixed installations (e.g., magnetohydrodynamic, thermionic and thermoelectric, and radioactivity).

10. New sources of power for ground transportation (storage battery, fuel cell, propulsion [or support] by electromagnetic fields, jet engine, turbine, and the like).

11. Extensive and intensive worldwide use of high altitude cameras for mapping, prospecting, census, land use, and geological investigations.

12. New methods of water transportation (such as large submarines, flexible and special purpose "container ships," or more extensive use of large automated single-purpose bulk cargo ships).

13. Major reduction in hereditary and congential defects.

14. Extensive use of cyborg techniques (mechanical aids or substitutes for human organs, senses, limbs, or other components).

Potential Impacts

This list is undeniably comprehensive, ranging over the whole scope of human activity. Obviously, the degree of likelihood of realization varies with each innovation. The Navy would be influenced in some way by almost all of these innovations, either as an institution, or as an organization embracing a large number of diverse Americans with a plurality of interests. The potential impacts of a number of these innovations will be discussed in later sections of this project.

15. New techniques for preserving or improving the environment.

16. Relatively effective appetite and weight control.

17. New techniques and institutions for adult education.

18. New and useful plant and animal species.

19. Human "hibernation" for short periods (hours or days) for medical purposes.

20. Inexpensive design and procurement of "one of a kind" items through use of computerized analysis and automated production.

21. Controlled and/or supereffective relaxation and sleep.

22. More sophisticated architectural engineering (e.g., geodesic domes, "fancy" stressed shells, pressurized skins, and esoteric materials).

23. New or improved uses of the oceans (mining, extraction of minerals, controlled "farming," source of energy, and the like).

24. Three-dimensional photography, illustrations, movies, and television.

25. Automated or more mechanized housekeeping and home maintenance.

26. Widespread use of nuclear reactors for power.

27. Use of nuclear explosives for excavation and mining, generation of power, creation of high temperature—high-pressure environments, and/or as a source of neutrons or other radiation.

28. General use of automation and cybernation in management and production.

29. Extensive and intensive centralization (or automatic interconnection) of current and past personal and business information in high-speed data processors.

30. Other new and possibly pervasive techniques for surveillance, monitoring, and control of individuals and organizations.

31. Some control of weather and/or climate.

32. Other (permanent or temporary) changes—or experiments—with the overall environment (e.g., the "permanent" increase in C-14 and temporary creation of other radioactivity by nuclear explosions, the increasing generation of CO_2 in the atmosphere, projects Starfire, West Fore, and Storm Fury).

33. New and more reliable "educational" and propaganda techniques for affecting human behavior—public and private.

34. Practical use of direct electronic communication with and stimulation of the brain.

35. Human hibernation for relatively extensive periods (months to years).

36. Cheap and widely available central war weapons and weapon systems.

37. New and relatively effective counterinsurgency techniques (and perhaps also insurgency techniques).

38. New techniques for very cheap, convenient, and reliable birth control.

39. New, more varied, and more reliable drugs for control of fatigue, relaxation, alertness, mood, personality, perceptions, fantasies, and other psychobiological states.

40. Capability to choose the sex of unborn children.

41. Improved capability to "change" sex of children and/or adults.

42. Other genetic control and/or influence over the "basic constitution" of an individual.

43. New techniques and institutions for the education of children.

44. General and substantial increase in life expectancy, postponement of aging, and limited rejuvenation.

45. Generally acceptable and competitive synthetic foods and beverages (e.g., carbohydrates, fats, proteins, enzymes, vitamins, coffee, tea, cocoa, and alcoholic liquor).

46. "High quality" medical care for underdeveloped areas (e.g., use of medical aids and technicians, referral hospitals, broad spectrum antibiotics, and artificial blood plasma).

47. Design and extensive use of responsive and supercontrolled environments for private and public use (for pleasurable, educational, and vocational purposes).

48. Physically nonharmful methods of overindulging.

49. Simple techniques for extensive and "permanent" cosmetological changes (features, "figures", perhaps complexion and even skin color, and even physique).

50 More extensive use of transplantation of human organs.

51. Permanent manned satellite and lunar installations—interplanetary travel.

52. Application of space life systems or similar techniques to terrestrial installations.

53. Permanent inhabited undersea installations and perhaps even colonies.

54. Automated grocery and department stores.

55. Extensive use of robots and machines "slaved" to humans.

56. New uses of underground "tunnels" for private and public transportation and other purposes.

57. Automated universal (real time) credit, audit and banking system.

58. Chemical methods for improving memory and learning.

59. Greater use of underground buildings.

60. New and improved materials and equipment for buildings and interiors (e.g., variable transmission glass, heating and cooling by thermoelectric effect, and electroluminescent and phosphorescent lighting).

61. Widespread use of cryogenics.

62. Improved chemical control of some mental illnesses and some aspects of senility.

63. Mechanical and chemical methods for improving human analytical ability more or less directly.

64. Inexpensive and rapid techniques for making tunnels and underground cavities in earth and/or rock.

65. Major improvements in earth moving and construction equipment generally.

66. New techniques for keeping physically fit and/or acquiring physical skills.

67. Commercial extraction of oil from shale.

68. Recoverable boosters for economic space launching.

69. Individual flying platforms.

70. Simple inexpensive home video recording and playing.

71. Inexpensive high-capacity, worldwide, regional, and local (home and business) communication (perhaps using satellites, lasers, and light pipes).

72. Practical home and business use of "wired" video communication for both telephone and TV (Possibly including retrieval of taped material from libraries or other sources) and rapid transmission and reception of facsimiles (possibly including news, library material, commercial announcements, instantaneous mail delivery, other printouts, and so on).

73. Practical large-scale desalinization.

74. Pervasive business use of computers for the storage, processing, and retrieval of information.

75. Shared time (public and interconnected?) computers generally available to home and business on a metered basis.

76. Other widespread use of computers for intellectual and professional assistance (translation, teaching, literature search, medical diagnosis, traffic control, crime detection, computation, design, analysis and to some degree as intellectual collaborator generally).

77. General availability of inexpensive transuranic and other esoteric elements.

78. Space defense systems.

79. Inexpensive and reasonably effective ground-based BMD.

80. Very low-cost buildings for home and business use.

81. Personal "pagers" (perhaps even two-way pocket phones) and other personal electronic equipment for communication, computing, and data processing program.

82. Direct broadcasts from satellites to home receivers.

83. Inexpensive (less than $20), long lasting, very small battery operated TV receivers.

84. Home computers to "run" household and communicate with outside world.

85. Maintenance-free, longlife electronic and other equipment.

86. Home education via video and computerized and programmed learning.

87. Stimulated and planned and perhaps programmed dreams.

88. Inexpensive (less than one cent a page), rapid high-quality black and white reproduction; followed by color and high-detailed photography reproduction—perhaps for home as well as office use.

89. Widespread use of improved fluid amplifiers.

90. Conferenct TV (both closed circuit and public communication system).

91. Flexible penology without necessarily using prisons (by use of modern methods of surveillance, monitoring, and control).

92. Common use of (longlived?) individual power source for lights, appliances, and machines.

93. Inexpensive worldwide transportation of humans and cargo.

94. Inexpensive road-free (and facility-free) transportation.

95. New methods for rapid language teaching.

96. Extensive genetic control for plants and animals.

97. New biological and chemical methods to identify, trace, incapacitate, or annoy people for police and military uses.

98. New and possibly very simple methods for lethal biological and chemical warfare.

99. Artificial moons and other methods for lighting large areas at night.

100. Extensive use of "biological processes" in the extraction and processing of minerals. (BB170)

WEAPONS

1. We do not pretend to cover the comprehensive range of possible future weapons systems; these are highlights only.

Future weapon systems of potential importance would include:

2. Weather Control - Systems permitting manipulation of meteorologic conditions. Examples might be generating or directing storms or, in contrast, inducing precipitation upwind, so that a nation dependent on water vapor could be subjected to years of draught, or generating or directing storms.

3. Subsurface Operations - The chief trend is toward facilitating operations at very great depths. Development may enable construction of submarines with diving capability of 20,000 feet or more. This would make 98% of the ocean floor accessible to submarines (missile, hunter, killer, and transport-cargo subs) and submarine-supported technology.

4. Aerospace Planes - Planes capable of achieving orbital flight from the earth's surface. Uses and significance of such systems are unknown.

Potential Impact

As noted, we do not discuss the potential impacts of weapons systems or weapons developments in this report.

5. Lasers (Disintegrator Rays) - High-energy, small angle light beams now possible. Could serve as basis of inertial navigation gyroscope 1 million times as sensitive as that currently in use.

6. Surface-Effect Ships - To cope with submarines, increased surface and speed maneuverability are necessary, and today's conventional vessels will be inadequate. Hovercraft and "captured-air-bubble" vehicles weighing 5,000 tons and capable of 100 knots in high seas may be feasible.

7. Robots - Sophisticated walking mechanism propelled across land, capable of sensing and aiming weapon at enemy. Similar robot pilot possible for bomb delivery machines on land, in air, underwater and in outer space.

8. Holography - Three-dimensional holograph-photography for use in reconnaissance and intelligence collection. System incorporates side-looking radar and "foolproof" cryptography.

9. Anti-Matter Devices - Particles (anti-protons) seeking out and destroying normal counterpart in energy burst.

10. Gravity Control - Anti-gravity device for individual fighters.

11. Doomsday Machine - Earth-orbiting satellite with nuclear fusion, tritium, cryogenics. (BM43, 95)

12. It is not likely that space will figure prominently in future weapon systems (e.g., orbital platforms) because of ease in detection, tracking, and, destruction. Increasing reliance will be placed on submarines as weapon platforms for both conventional and nuclear systems. (BM43, 95)

13. Discussing the possible effects of various technological developments, Rescher anticipates that the proliferation and sophistication of modern weapons of mass destruction could result in downgrading of the characteristic of national pride, and upgrading of mankind-oriented values. (BB16)

ENERGY

1. Population growth places greater demands upon mineral resources. While man need not be deprived of vital elements found in the oceans and earth's crust, everything will be more costly in terms of energy, and human affairs will necessarily become more highly organized in order to carry out the increasingly complex tasks of maintaining adequate stores of essential resources. (BB50)

2. Our present industrialization, itself anachronistic, constitutes the only foundation on which a future civilization capable of exploiting and utilizing the vast resources of energy now hidden in rock, seawater, and the sun can be built. (BB50)

3. In the United States, each household's electricity consumption has quadrupled in the last 20 years and total national use has increased from 345 billion kilowatts to 1.5 trillion kilowatts. The toll on the environment has included an increase in construction of hydroelectric dams which flood the lands, an increase in steam generators which emit fine ash and sulphur dioxide, and more than 100 atomic electric plants in 31 states contributing to thermal pollution and radiation. In the technology environment, conflict tradeoffs are difficult to make because they would

Potential Impact

As cited elsewhere in this report, many authorities are convinced that an energy crisis is shaping up, with very grave implications for a technologically-oriented agencies. It is not difficult to foresee that such a crisis may indeed arrive. As the Navy faces the future, the possibilities for energy conservation may be given closer attention and higher priorities.

Potential Impact

Increasingly intensive searches for natural resources related to generation of energy will doubtless lead to certain adjustments in relations among various nations, and will almost certainly involve attempts to exploit the oceans and seabeds. As these activities proceed in both peaceful and potentially tense environments, the Navy will be involved.

involve changes in the economy's decision-making process and alter the pursuit of a higher standard of living. (BN511)

4. A panel on energy conservation at the annual meeting of the American Association for the Advancement of Science suggested the need to relieve the nation's energy shortages by reducing the demand for power, not by increasing the supply.

Dr. Barry Commoner, a biologist at Washington University in St. Louis, is a leading proponent of this view and cites corroborative data drawn from a joint study being conducted by the Association's Committee on Environmental Alterations and the Scientists' Institute for Public Information, which Dr. Commoner heads:

- Industrial consumption of electricity has been doubling every 14 years, but efficient utilization has been declining since 1947.

- Synthetics, plastic, and aluminum are power-intensive processes as opposed to power-thrifty.

- Other experts, especially those connected with the power-energy industry, contend that more power is needed to clean up pollution.

- Richard Stern, architect, notes changes in building materials and designs

Potential Impact

The Navy will probably be involved in various efforts to provide shipborne-generated energy provided from off-shore to coastal installations in underdeveloped countries, especially for special occasions over limited periods.

increase the power cost of erecting and operating buildings.

Conversion efficiencies for electricity should rise from 37% to between 45 to 48% by 1984. The whole field of large-scale electricity generation may well be changed if magneto hydrodynamic (MHD) methods of power generation are developed.

The power station of 1984 (nuclear or fossil fuel) might consist of an MHD 'topping' generator exhausting into a conventional steam-driven generating set, permitting 60-65% efficiency or feeding a combined thermonic-thermoelectric system. With respect to the possibilities of one-site, silent and efficient electricity generation by fuel cells, attainment of conversion efficiencies of 60% are considered realistic by 1984.

High-speed light, direct-current electric motors could lead to revolutionary changes in methods of traction.

The new look in car design will be a fuel cell driving an electric motor built into the hub of each wheel. Transmission systems, as we know them, would be eliminated. Such innovations would mean maximum torque at minimum engine speed, a pollution-free exhaust, and complete freedom to design the car around the occupants rather than engine, plus 60% conversion efficiency.

Fuel cells are particularly suited to replace conventional diesel and gasoline-driven generators. In the 10KW range, they are silent, have no moving parts and have 60% conversion efficiency (rather than 10%). Plans for a fuel-cell-powered submarine have already been developed, and these same technologies could also be applied to farm equipment, motor boats, etc.

Domestic electricity could be radically altered by installing in each house and small factory a fuse-case generator running off piped hydrocarbon gases. Distribution of gas is much cheaper than distribution of electricity. Such a system would have an added advantage in that the hydrocarbon fuel cell would probably operate in the 200-400°C range, and an integral central-heating system could be built into each generator, thus making effective use of the heat given out during the electricity-generation process.

The development of cells which operate on natural gas will put an end to the burning to waste of natural gas in the arid, oil-producing areas of the world. The gas will be used in large units to generate electricity, to operate irrigation pumps, and to provide local electricity supplies. In such areas, thermonic and thermoelectric generators may also convert solar heat into electricity.

Thermonic and thermoelectric convertors will almost certainly contribute towards reducing the appalling waste of heat which occurs in large industrial plants. For example, the average steelworks could generate enough electricity from the heat lost from hot metal to operate all auxiliary pumps, fans, and lighting in the works.

Methods of large-scale electricity storage in chemical form which can be quickly regenerated in a fuel cell will enable peak loads and unexpected demands to be met without the need to install large power plants which would only be used intermittently.

A biochemical fuel cell which converts energy available in biochemical systems into electricity—could generate enough power to operate a heart "pacemaker" in a patient. (BB58)

5. Practical nuclear power sources for every nation on earth are well within our technical capability in this century, provided the 'unforeseeable" element of political and financial support is exerted. To answer the staggering future energy needs of the world, nuclear power is the most efficient source known for electric power, and could be developed in either of two systems: small, self-contained reactors could serve individual buildings and complexes, or vast distribution systems could be set up to draw from huge multi-megawatt nuclear plants. Nuclear fusion, still a relatively undeveloped field, could provide vast energy sources without the side effect of radiation; but a great deal of research is necessary to make this practical. (BM55)

6. Fusion reactors hold the promist of producing electrical energy very economically, directly from heat with no moving parts. Since a major impediment to the development and use of desalination systems is the availability of cheap electrical

power, the advent of controlled thermonuclear power might also trigger implementation of large-scale seawater conversion projects.

Solution of the thermonuclear gas containment problem might lead to new forms of space propulsion based on the high speed ejection of ionized plasmas. (BB16)

7. A Delphi survey contemplated the implications of a successful demonstration of continuously controlled thermonuclear power, and suggested these possibilities:

- Great cost reduction in electric power, and as a result, increased agricultural and industrial productivity.
- Reduction in atmospheric pollution.
- Technological and industrial growth in new areas, particularly in underdeveloped nations.
- Widespread obsolescence in coal and petroleum industries, physical relocation of coal-mining family; and retraining of workers.
- Population shifts to new areas and massive decentralization of urban clusters.
- Development of new forms of space propulsion systems leading to interstellar probes.
- New political ramifications, including—military use of thermonuclear power by nations having this technology. Competition among superpowers offering to transfer this thermo-nuclear know-how to less developed countries.
- Heavy government expenditure to develop and build commercial thermonuclear plants.
- A laboratory curiosity, with only minor practical applications, since most power plants will employ readily available uranium. (BM61)

8. Another survey of authorities in the field elecited a similar range of responses to the concept of developing systems which will permit transmission of significant amounts of power by wireless means (50 KW for 50 miles).

- Utilization of new power sources for many applications—beamed power for remote data-gathering sites, satellites, weather stations, high speed transportation systems, and aircraft.

- Facilitation of ocean exploration.

- Emercence of new kinds of air safety problems; airliners must avoid power-transmitting beams.

- Unforeseen consequences to the ecology, such as detrimental effects on birds. (BM61)

9. The possible widespread use of superconductors in the $20^{\circ}K$ to $30^{\circ}K$ range allowing liquid oxygen to be used as a coolant could mean more economical transmission of power over very long distances and cheap electric power available to everyone, everywhere. (BM61)

AUTOMATION AND COMPUTERS

1. Projections concerning the role of automation in the future vary in nature but unanimously reflect the increasingly dominant influence of computers. Conscious that they are already permeating nearly every facet of our lives at all levels, the consensus is that the next several decades will see an even greater utilization of and reliance on computers and computer-assisted systems.

2. ADP (automatic data processing) has undergone a phenomenal growth over the past two decades and continues to be a major tool of Research and Development (R & D). Anticipated technological advances both in machinery and software techniques and projected new applications presage an even greater influence of computer technology on lifestyles of the future.

A foretaste of the future was provided by the account of the recent initiation of actual construction in Columbus, Ohio, of a completely automated, self-service bank. It will provide all normal banking services, but no human will be on the premises. (BN302)

3. It may be that the applications of systems analysis will ultimately be limited

Potential Impact

The potential for automation in the Navy is almost unlimited, from mathematics classrooms and storage warehouses to entire ships. Navy management systems; personnel records; information storage and retrieval; materials handling; and all the other processes required in large organizations, communities, and facilities are subject to automation in pace with automation of such procedures in general society. The Navy has a number of other mission-requirements, however, which can be facilitated by automation. Two areas are central—the ship in its maritime environment, and the fleet in a combat environment. A number of elements of ship operation have already been automated, and automation of others is feasible—or will be. To be distinguished from features related to operation at sea in any environment (navigation, cargo-handling, etc.) are features related only to combat environment (intelligence gathering and processing target recognition, fire control, etc.). Various aspects of the latter, too, have been automated or are susceptible to automation. Beyond

only by the funding needed to implement programs. The well-organized problem-solving approach of systems analysis will be highly successful in application to a wide variety of both defense and non-defense problems. (BP259)

4. A trend toward machines that will process data as and where they are found is predicted, but processing speed is still constrained by the speed of light. The cost of the machine itself will not change, although performance will be enhanced considerably. Related technical developments (such as magnetic tape) tend to slightly reduce cost of machines of given performance programming. There is increasing efficiency of symbolic languages and increasing standardization of programming. (BB58)

5. Automated machinery using electronics as its brain and hands, may take over much of the manual work done in factories. This with an increasing overall population growth could create an explosive social and economic problem, unless anticipatory planning is undertaken. (BB18)

6. In pointing out the applications of ADP in non-technical, sociological areas, Harrison Brown observes that the economy a certain point in some activities, however, the Navy will continue to prefer the presence of humans to their absence, for a number of reasons.

Potential Impact

The Navy will be as interested as any other social institution in automating access to information in its primary special interst of naval affairs. Data concerning any particular aspect of naval affairs are located in a number of locations would be highly desirable. Central library resources available to the Naval Academy, the Postgraducte School, the Naval War College, and other centers, including the Navy staff, would facilitate study and research in staff problems. In early stages, such networks may be facilitated by shipborne data banks visiting coastal locations for temporary exploitation.

Potential Impact

Similarly, Navy access to data banks outside the Navy (e.g., a National Data Bank) would eventually become desirable, both for inputs and outputs.

of an industrial society consists of a vast interlocking network of causes and effects. Mathematical relationships between the various parts of the network are extremely complicated and are similar to the relationships that exist between the component parts of a variety of inter-locking systems, such as the ecological assemblages of living things.

Once the fundamental principles of the economic network of a given society are clearly understood, it is possible that computing machines will take over the task of timing investment expenditure, forecasting business activity, and plotting the economic course of a nation in such a way that major economic oscillations can be avoided.

7. The need for an increase in information automation result from increases in population, education, R & D, and application which will continue into 1980 and beyond.

The digital computer is the heart of the new information system, and its major impact will be as an information processor.

By 1980 the speed of computers will probably increase to a level of about 1 billion operations per second, and the cost per operation will have decreased by a factor of about 200 from 1967 levels.

Potential Impact

The image of an automated organization vs. the misgivings of individual members of the organization, in matters which affect them personally, will continue to grow in Navy concern. Every human being will be aware that when you point out to a human being that an error has been made, he corrects it, but that when you point out to a computer that an error has been made, nothing happens until you find the human who controls the computer. Especially in decisions affecting personnel, repeated assurances will be necessary, to the effect that human considerations govern decisions, not computer efficiency. Such misgivings will be particularly sensitive concerning decisions which affect careers significantly, such as in selection for promotion, selection for special assignments such as attendance at war colleges, selection of individuals to be eliminated during a Reduction In Force, etc.

By 1980 the total memory of a reasonable number of direct-access computers will suffice to store and process in "real-time" all the significant information in the world's libraries as of 1967. (BB242)

8. In ten years, computers have become 10 times smaller, 100 times faster, 1,000 times less expensive. The American population of computers increased from 1,000 in 1956 to 30,000 in 1966, and a total of 100,000 is projected for 1976. Speed of computation has likewise increased from 12 billion computations per hour in 1956 to 20 trillion in 1966, and it is estimated that equipment in 1976 will be capable of 400 trillion computations per hour. (Sarnoff)

The 6th annual report of Harvard's "Program of Technology and Society" under Emmanuel Mesthene contains interesting summaries:

- At present computers are still being used to move paper instead of decision-making, and this trend is continuing.

- There is not the slightest sign of a displacement of the traditional leadership elites of top and middle management in government by the infomation specialists.

Potential Impact

Other foreseen impacts are discussed under Social and Cultural. In addition, various changes forecast in this field overlap changes in the communications field. Some foreseen impacts which may be somewhat ambiguous in classification are discussed under Communications.

• Public money was spent, and..."This may represent a typical instance of early development costs of a powerful tool before its true potential is realized."

• The socialist or communist nations are at the same stage as capitalist countries. (BN166)

INSTITUTIONS

9. • Within ten years, thirty cents out of every investment dollar in manufacturing will go for automated machinery and equipment. (BM94)

• International computer links for business transactions will provide continuous figures on the level of purchasing activity, and on comprehensive analysis of the purchaser. (BM94)

10. The cumulative predictions of several authors (BB58, Sarnoff, S.P., Diebold, S.R., Macy, S.R., BM95) is that advances in computer technology over the next several decades will permit a wide range of new applications:

11. • Electronic miniaturization, sensing systems, memory devices, simplified access, verbal input/output systems. (BB16)

12. • Intercommunication capability, allowing computers to talk to each other and integrate information.

• International message transmittal.

• Increase in artificial intelligence—i.e., new ways of programming other than generating native intelligence.

• More sophisticated technology and increased processing speed, facilitating surveillance of individual records.

• Computer simulation leading to greater understanding of modeling, generic codes, and protein synthesis. (BB58)

13. • Home and office consoles with access to city-wide data libraries.

• Communication to all points on earth.

- Medical profiles on every person and remote medical diugnoses.
- Financial transactions controlled from central credit exchange.
- Large-farm sensors analyzing soil, weather, temperatures, crops, seedtimes, amounts of fertilizer, harvesting times.
- Desktop input/output terminals with display devices and information recording/storage capability.
- Capability to handle thousands of accessions simultaneously.
- Condensation/synopsizing of literature.
- Language translation.
- World-wide storage and dissemination of graphics, photographs.
- Voice recognition systems.
- Heuristic Machines capable of learning, recognizing patterns, and devising own strategies in pursuit of solutions and goals.
- Extensive application by government and other large, bureaucratic organizations in all areas of administration, processing applications, testing, test evaluation, scoring, letterwriting, personnel management, job data banks, etc.
- International data banks, accessible to managers in business and government.
- Computer experimentation (less expensive and more reliable) to replace laboratories.
- Postal services of today replaced by point-to-point digital transmission of data.
- Universal Personal Identification code (probably a voiceprint) leading to a cashless and checkless society.
- Voting in realtime.
- Microelectronic stimulation of brain to produce sight and sounds for blind and deaf.

• Small individual computers controlling climate and lighting in home and office, and systematic home information-retrieval banks incorporating hookup among brokers, retailers, etc. and scheduling of maintenance, budgeting, and medical care.

• Three-dimensional replication of living and moving objects.

• Idiom — recognition and generation capability.

• Increased automation of weapons systems and shipboard control of communications, electronic warfare, management, etc., providing sound base for development in civilian communications. (BM43, 95)

14. • Among the many devices under development, a direct access, time-shared computer system, with remote terminals (such as teletypewriters, dial telephones, or light beam "pencils") is considered the revolutionary development.

Other features anticipated for future computers are:

. Up to 250 users will be able to employ the computer simultaneously.

. By 1980 there will be a series of computer-based national information systems for all published literature in certain fields (e.g., scientific).

. Legal citations will be computerized in an index system.

. Interdependence of libraries will increase with computer technologies. They will become complete information centers.

It is predicted that the potential impact on American society of having a substantial amount of recorded information which can be manipulated and communicated by written and oral modes will exceed the impact of the automobile. (BB242)

15. Government projections indicate that, as a result of increased automation, 50% of jobs in 1976 will not have existed in 1966; occupational obsolescence will occur with greater frequency; and people can anticipate two to three discrete careers in a lifetime, and continuing education throughout a lifetime.

With respect to machines' physical capabilities, printing will range from a few words per minute to hundreds of lines per minute, with the same rate for instantaneous recording and transmission of graphics.

Eventually, newspapers will be reproduced on the home comm-wire center. In addition to texts, a professor's "notes" can be circulated to homes. The same process can be applied for retrieval of texts, theses, articles, etc. Lawyers will be able to review statutes, decisions, and precedents at home, and similar data will be available to businessmen.

Diebold sees computers of the future as including a variety of innovations, in addition to those already cited:

- Input/output units on individual desks, with answers on a screen, and a capability for recording/storing information, and copies if desired.
- Thousands of people using the same data bank simultaneously.

Possible milestones in computer development include:

- Dramatically lessening costs.
- Intervening stages important but transient (e.g., newspaper printing)
- The major problem may involve people, in training and selection, in orientation—overcoming uneasiness.
- Acceleration in rate of learning, travel and commerce or orienting people to accept and use automation.

Four new areas of entrepreneurial opportunity resulting from proliferation of computer use are suggested:

- Industry to supply the software and the equipment.
- The data utility field providing cheaper time-sharing services.
- Inquiry industry publishing field of future—sale of proprietary data.
- Computer-based educational system
- Rate of learning information, travel, and commerce will be changed by the computer.
- Samuel predicts two separate scenerios for western and communist countries:

(1) Individuals owning private computer-(Western)

(2) Individual accessing a small terminal connecting with large state-owned computers (communist)

In both instances massive compilation will be required, with information readily accessible to everyone.

He sees applications also in rapid language translation, limited application as teaching devices, and enhanced process control with attendant automation, but a shorter work week and displaced people as a result. (BB58)

16. Clarke anticipates that homes and offices may contain communication consoles with access to remote data banks, drastically reducing the need for commuting and face to face interchange, influencing transportation and highways.

Such facility of communication may make direct democracy possible by home voting on key issues, and could have drastic impacts on concepts of political representation.

W. H. Ware also forecasts that every home will have a personal computer console—like any other appliance--by the 1980's. (BF13)

17. It is expected that research in specialized computers for teaching will increase.

The technology of learning will be extended. Physiological instrumentation will become more accurate and efficient.

Input/output devices for computers might eventually permit the teaching machines to operate in a conversational mode. (BB16)

18. One of the implications of Man-Machine Symbiosis, enabling man to extend his intelligence by direct electromechanical interaction between his brain and a computing machine, is that computers may become colleagues in a real sense.

Certain human intellects may prove more favorable for machine direction. Only the best minds may be selected for machine control functions. (BB16)

19. In the health field, organized personal data could be scanned in a number of ways. Statistical health trends in the population could be determined with

greater rapidity and accuracy. For example, the relationship between cigarette smoking and lung cancer might be established without question by a single computer routing. (BB16)

20. Another factor to be considered in connection with advancing computer technology is the preservation of privacy.

If "bugging" were to become a popular pastime, we might find new ways to use leisure, but we would probably also have to invent new ways to insure privacy. For example, we might have houses with invasion-proof rooms, special anti-tamper telephone lines (at a higher rate, of course), and a "bug"-removal service as regular as the gardener.

As computers extend their scope, will we become more immune to receiving their impersonal instructions? (BB16)

21. Continued automation in commerce and industry, such as an increase by a factor of 10 in capital investment in computers used for automated process control, will improve the efficiency of controlled and planned economics. In the USSR, for example, automation will improve the planning of resource allocation, the distribution of goods to meet consumer demands, and the setting of prices. In democracies, computers will extend the scope of bureaucracies, possibly at the expense of privacy.

Means may be found for equitable distribution of over-abundance to raise the level of the underprivileged nations. (BB16)

22. It is felt that automation will speed industrialization of underdevoped areas. (BB57)

23. Rescher feels that possible effects of various technological developments might include:

- Downgrading of progress and of material values generally

(partly because the things at issue will come to be taken for granted, partly because their increasing realization will markedly fail to bring on the millenium).

- Upgrading of handicrafts, workmanship, and skilled and unskilled services generally (reevaluation of labor-intensive means of production; potential explosion of the "problem of leisure" myth and the "spectre of mass technological unemployment") (BB16)

24. From a survey on the potential impact of a computer which comprehends standard IQ tests and scores above 150 (where "comprehend" is to be interpreted behavioristically as the ability to respond to questions printed in English, possibly accompanied by diagram), the following effects were predicted:

- More precise understanding of how the human brain functions.
- Self-replicating computers and more advanced computers designed by other computers.
- Development of meaningful, or at least amusing, hardly ever boring, pastimes.
- The raising of philosophical and speculative questions regarding human significance. (BM61)

Another canvass was made to determine the repercussions of the establishment of a central data storage facility (or several regional facilities) with wide public access (perhaps from home) for general or special retrieval of information, primarily in the areas of library, medical and legal data. Projected possible impacts are as follows:

- Individual citizens becoming proficient in law and medicine, through easy availability of the relevant data in the home.
- Use of home terminals for education, transferring the home into a part-time school; growing competition between the traditional teaching profession and advocates of programmed instruction.
- Great revolutions in library sciences, including greatly improved methods of searching for particular subjects.
- Improvements in social-science research.
- Information storage becoming a salable service, resulting in widespread revision of business practices.

Information overload; the problem will be to select from the available plethora of information that which is important and relevant to the individual.

- Invasion of privacy (assuming personal date on individuals can be retrieved)
- Rise of new methods of computer-aided crime. (BM61)

25. Possible cultural effects of complex robots which are programmable, self-adaptive, and capable of performing household chores, such as independently preparing meals and cleaning or otherwise disposing of dishes, were assessed as follows:

- Robots replacing the automobile as the central feature of our economy.
- More women entering the labor force.
- Increased demand for educational and recreational services.
- Development of a counter-trend which places high value in "personally" done housework and menial tasks, such as, homecooked vs. robot-prepared meals. (BM61)

26. What will the relationship be between people and their machines? The profession of robot repair and servicing may gain status. (BB16)

COMMUNICATIONS

1. Advancing technology in communications has begun to indicate a need for unification of what has traditionally been a collection of complementary but separate communications services. The national picture is diffuse and so is the international.

In an integrated system, for example, a person in 1980 could have a private telecommunications center with television, tape recording system, 2-way picture phone, high-speed electronic printer, and a computer and display unit.

A unified national-international network will employ cable transmission, microwave systems, and satellite relays; and eventually laser channels will be used. (BB242)

2. The technical problems of a world-wide communications network are solvable; but the economic, social, and political consequences of point-to-point communications anywhere on earth are very complex. Costs will continue to be a factor, and more sophisticated service will have to be justified. (BB242)

3. For example, research involving many millions of dollars will be undertaken on the technical aspects of television satellites before they are ready to launch. Unless similar research is done on the programmes they are to transmit, television satellites will be nothing more than a new toy in the sky. Too often in the past, scientists and engineers have perfected a new machine, as for example the motor car, without giving due thought to the social consequences of their invitation. Television satellites will be in space in a few years' time. Today we can foresee the social consequences of this new invention, which could, if used for the benefit of mankind, solve the vital question of population explosion. If not, there will be 3,500 million starving human beings in the year 2000, who will rightly curse us, who knew the answers, but were not prepared to put them into practice. (BF13)

4. In a meeting held recently at the Byurakan Astronomical Observatory in Russia, Soviet and American scientists from several disciplines addressed themselves to the possibility of communication with life on other planets. The scientist members admitted that too little was known about how life began and how or by what means they might communicate.

One scientist remarked that everything was uncertain. "What if everyone is listening and no one sending signals"? The conference concluded that more research was needed in this field and that they (the members of the conference) would continue to explore the problem. One thing was certain. This group of men is serious on their intentions to establish effective communication with other worlds. (BN481)

5. The budgeting of future civilian space programs is expected to exceed one per cent of GNP, but potential benefits accrued will justify the investment. Some of the benefits may include:

> Observations made from earth orbit can materially add to man's comfort on earth. For example, plankton distribution, location of meatfish herds, diseased orchards, and crop growth patterns, as observed from orbit, can materially add to the earth's food production.
>
> As population grows on the earth, waste disposal may become a significant problem. Perhaps solar probes can be used to rid the earth of noxious wastes by shooting these packages to the surface of the sun.
>
> Perhaps the day will also come when we seek to minimize our population pressures through colonization of nearby habitable planets. Depletion of the earth's resources may cause us to look to space for replenishment.
>
> The global communications systems possible through the use of space satellites will bring the nations closer together and illustrate, hopefully, that men are still men the world over. (BB16)

6. Gross, on telecommunications is space, suggests that one of the most striking future developments will be bases for space exploration operating automatically on the surface of themoon, which will employ communications networks of incredible complexity in terms of volume and range.

Some problems facing development of distant probes are:

(1) Detection

The theory of modulation must be expanded so that (in the exploration of space, and search for other intelligent life in the universe) we will be equipped to detect whether or not a received modulation is deliberately modulated, even though the means or content of the modulation may be entirely new.

(2) Time

Time necessary for propagation of signals is a serious constraint, since there is no way of accelerating radio signals to velocities exceeding the speed of light.

Gross expects that an international body will be needed to prevent incompatibilities and interferences between space and terrestial communications (including communication satellites) and to plan for the efficient development of these two aspects of communications. (BB58)

7. Increasing capabilities in satellite and communications technology will permit direct satellite television broadcasting. Other possibilities include international time-sharing of computer complexes over high-density data networks, advances in weather forecasting and control, oceanography, navigation and world-wide resource surveys, and increased potential for highly sophisticated surveillance systems. (BM43,95)

8. Laser technology is still in its infancy, yet vast research efforts are underway. Lasers are creating an exciting new field called holography, in which light waves from an object can be recorded on film and later reproduced in mid-air as a three-dimensional photograph. Most laser research, however, is going into the eventual development of a long-range communications system, using light waves. Many obstacles need to be overcome first, but the laser's unique properties, including highly directional, coherent, monochromatic light and its extremely wide frequency range, make its use particularly promising. Lasers may one day provide us with instant interplanetary television. (BM43,95)

9. Improvement in computer-assisted information-handling capabilities will continue to increase the rate of person-to-person information flow faster than growth in GNP, population, or any other leading indicator. (BM 43,95)

10. The widespread use of superconductors in the $20^{\circ}K$ to $30^{\circ}K$ range allowing liquid oxygen to be used as a coolant is seen as possibly leading to development of improved communications and electronic devices (higher pulse powers, smaller size for certain items, etc.). (BM61)

11. Steinbuch predicts four innovations in communications technology for the year 2000: (Some of these predictions obviously parallel or duplicate some in the Section on Automation):

(1) Direct satellite television:

(2) Information banks probably will appear within the next two decades.

(3) Information grids probably will connect the information banks, also within the next two decades.

(4) Teaching programs accessible by dialing probably will come into use less than twenty years from now. (BFI3)

12. Another author projects future achievements in communications technology as including:

- laser connections for sound-and-sight communication at any distance
- microwave channels carrying television, telephone, facsimile newspapers, telegraph messages and computer data
- computer centers linked to institutions
- direct broadcast satellites (DBS) beaming into homes and community centers

Several questions regarding the impacts of such developments are posed:

- will a universal language emerge?

Potential Impacts

Many of these predictions of developments in communications will achieve impacts on the Navy common to impacts achieved on all other large organizations in American society—e.g., console in every home and office, teaching machines activated by dialing, some applications of laser technology, multi-purpose microwave channels, and others. Other impacts will be relatively unique to the Navy in that they will involve not only one ship at sea or even a number of ships at sea, but an integrated fleet of ships operated over long periods of time in continuous direct interrelationship. Communications in such conditions have been conducted by flags, lights, flashes, and other signals until modern means appeared in the forms of radio, radiotelephone, television, and other devices. Exclusive of automated control devices under electronic surveillance, various uses of closed-circuit television appear of potential interest to the Navy in the future. With multi-ship participation in systems of audio-visual interchange, a number of personnel activities might be conducted without physical movement of persons from ship to ship; for example, investigations; conduct of instruction; dissemination of orders simultaneously; the conduct of courts-martial; and, perhaps, medical diagnosis.

- can DBS be used for literacy programs in developing countries?
- what sorts of copyright problems will result? (BB242)

13. The development of image transmissions over communications channels will include using xerography to make printed copies and the coupling of telephone images of the people talking. Rapid copying will thrive. (BB242)

Potential Impact

The utilization of television at sea would seem to make feasible interception by hostile agencies. This may provide on occasion a particularly revealing category of intelligence, viz, the opportunity to "see inside" a ship at sea.

14. The individual, portable, 2-way communication device (portable telephone) carried by most Americans is foreseen to have the following potential effects:

- loss of privacy anywhere
- chaos in radio frequencies, resulting in rigid licensing by local and federal authorities
- decentralization of corporations
- better information on the whereabouts of one's children; increasing generation gap as a result of annoyance at checkup by "mom" after midnight
- increase in number of telephone conversations. (BM61)

15. Another innovation, the general use of communications systems which carry at least 100 video and information channels into average homes, will have a variety of repercussions.

The implementation of wide-band communication systems for home service use would lead to the development of inexpensive microwave communications receivers.

Automated voting procedures would require new telephone switching equipment if accomplished over telephone lines, and would spur the development of very large memory computers located regionally and capable of communicating with each other.

Availability of a large number of TV channels might affect newspapers and magazines greatly, particularly if the home TV sets were equipped with video tape recorders or facsimile printers. One channel might carry only local news; another, world and national news; a third, human interest and feature stories. One station might cover the stock market (automated stock purchasing?).

Use of some of this channel space might replace local newspaper advertising. Perhaps the voting machines could be used to place orders for merchandise.

The new devices associated with this development would spur the electronics and automation industries. (BB16)

Potential Impacts

The Navy will, of course, be interested in developments which improve communications within the categories of surface-to-surface, surface-to-air and vice versa, surface to undersea and vice versa, air to undersea and the reverse, and undersea to undersea. Predictions as to the availability of such developments are beyond the scope of this study. However, effective undersea communications, for example, will doubtless further undersea developments in general.

16. Pierce anticipates that advances in the fields of digital transmission, millimeter-wave waveguides, coherent light beams, and satellite communications systems will have a great impact on world society.

The development of valuable technology of communications may heighten nationalism and hamper the old non-political internationalism so as to seriously delay the development of satellite communication systems, or it could sweep away vestiges of the past. (BB58)

Potential Impacts

Navy ships may be able to provide a number of facilities afloat which may become uniquely valuable in particular circumstances involving LDC's or other foreign countries, perhaps as general projectors of television propaganda, news, official communications, or entertainment.

17. Clare provides something of an immediate summary in predicting that telecommunications of the future may:

- remove the need for the majority of personal contacts in business operations, conferences, etc.
- facilitate the application of digital encryption to confidential matter

- supply reference data on demand for all
- permit combination of visual transmission with telephones
- facilitate remote surveillance systems

He suggests further that enhanced communications capabilities would permit decentralization of industry and population and could have profound effect on the nature of, and solution to, urban problems.

Recognition of the latent need for people to communicate with each other will ensure a vast extension of the telecommunications network, coupled with a significant change in the concept of its place in modern society. (BB58)

TRANSPORTATION

General Projection

1. Advances in transportation technology will continue as a major focus of technological and social concern over the next several decades. The need for accelerated research and development efforts in this area has been well established. From urban traffic control to space-travel networks, future conditions of mobility will affect us all, and the evolution of transportation will alter, and be altered by, future lifestyles.

Developments already underway point up the advances we might expect over the next several decades.

2. Research into magnetism and superconducting magnets, made possible by new high-energy power sources, may one day result in surprising new uses for magnetic force. One possibility is a wheel-less railroad in which cars, powered by strong magnetic forces, would be suspended in the force field between opposing magnets. Frictionless bearings are another possibility.

At least one company is doing research on an engine with no moving parts, powered by a magnetic fluid that turns heat directly into electricity, and another is using huge magnets to push metal into shaped dies permitting forming jobs previously thought impossible. Superconducting magnets may some day be used to confine superhot plasma, to protect astronauts from cosmic radiation, and to increase resolution in electron microscopes so that atomic arrangements may be actually seen. (BM51)

3. By the year 2000 many products will be transported by pipelines—crushed ores, grains, etc.—replacing traditional freight-movement. Maintenance-free electric motors will begin displacing internal-combustion engines, and improved mass transportation systems will evolve with advancing development of the monorail and closed-tube vehicles. (BG2)

4. Widespread use of superconductors in the 20° K to 30° K range, allowing liquid oxygen to be used as coolant, is expected to lead to development of techniques which would make the electric car practical (higher efficiency batteries, fuel cells operating on evaporating hydrogen, smaller motors with improved efficiency, etc.). It could also precipitate development of magnetic suspension techniques for high-speed transportation systems. (BM61)

Freight

5. Air freight accounted for less than 1% of total cargo movement in the United States in 1967 but is expected to increase by 10 to 20-fold. While more expensive than surface transport, it permits a market range to be extended. Technological improvements, such as the new larger engines and specially designed military cargo planes e.g. (the C5A) will ensure improved cost-effectiveness of future air freight transportation. (BB242)

6. The railway is particularly suited to heavy hauls. It constitutes a self-contained system and therefore is well suited to techniques of control and optimization (cybernetics). Technical improvements have included automatic couplings, automatic routing, containerized cargo handling and gas turbine and electric locomotives.

Many changes affecting freight movement within the United States tend to be slowed down by institutional factors, e.g., ICC and ownership rules for truck lines and rail carriers. Labor unions insist on a high degree of job protection and high useage rates, so that, for example, the American Merchant Marine has declined in the last 20 years. (BB242)

Auto/Innercity Transportation

7. A major problem in transportation will continue to be that of coping with urban traffic. At present, completely automatic steering and control of vehicles has not been developed to a sufficient degree of reliability to justify replacement of human guidance.

Centralized computer control of urban road traffic will be operationalized.

By 1980, electronic and other driver aids will increase highway capacity by 50%, increase average speed by 50%, and cut accident rates by one-half.

1984 will see further development of new forms of land transport (hovercraft, monorail, travel belts); but there is little prospect that these will completely or even largely replace the motor vehicle, with its advantages to the individual. (BB58)

8. In urban and commuter transportation, it is contended that the more economical form of urban mass transportation is the subway or surface rail car. One author feels there is a passenger resistance to developing this field because the system is comparatively inflexible, often over-crowded, lacking in privacy, and basically uncomfortable; but there are obvious objections to this view,which cite efficient public transportation systems in other countries.

There is the possibility also that a one-or two-passenger commuter may be developed for urban transit. Run by electricity or gasoline, it could have its own right-of-way and parking facilities. (BB242)

9. Many solutions to urban traffic problems have been proposed. Hamilton and March advocate construction of totally new transportation systems rather than attempting to improve or upgrade existing ones. As an example, they suggest building personal transit systems employing "Dial-a-Bux" feeders to provide two-to four-passenger vehicles which would operate in automated guideways. (BM67)

10. Myers favors an evolutionary approach—upgrading of rail systems, introduction of electronic flow controls on highways, redesign of buses, and computerized real-time dispatch systems. (BM67)

11. Wolf considers the car the best means of transportation with respect to door-to-door service and high speed transport, except in the central core of cities, where congestion and parking are problems. He recommends the use of small electric-propelled vehicles built to operate on streets for short trips, and suburban travel on automated guideways for 60-mile-per-hour commuter trips. Concentrated core cities would also have rail and express bus systems and electric vehicles, but no private automobiles. (BM67)

12. It is felt that widespread use of automobile engines, fuels, or accessories which permit operation without harmful exhaust would precipitate a number of changes:

- Solution to the problem of air pollution, and as a result, continued acceptability of the use of automobiles.
- Higher efficiency of engine performance.
- Increased traffic congestion, as the smog-less automobile is allowed to proliferate.
- Delay in the development of high-speed transportation systems and competitive vehicles.
- Continued economic domination by the automobile industry. (BB342)

Ocean Transport

13. Watanabe addresses the future of ocean-borne transport in the following statements:

> The lines of improvement in modern ships are: (1) larger ships, (2) higher speeds, (3) more economic operation, (4) better navigation, (5) greater comfort and safety, and (6) greater reliability. By these trends, ships are changing for the better. If we look back over past changes, we see that it is not impossible to foresee the actual outward appearance of future ships.
>
> Generally speaking, one recent tendency has been for ships to become specialized types, such as ore-carriers and tankers, and this tendency will be intensified further until the differences between the types are very marked. For example, ore-carriers, tankers, and similar kinds of ships will increase in size as far as operating economy allows, with increase in speed being of rather secondary importance. With passenger ships, comfort and safety are primary consideration, but speed is not far behind.
>
> It is generally believed that a larger ship pays better. It is, however, known that the merit of a larger ship at present attains a maximum at, say, about 90,000 deadweight tons, showing a decrease above that. There are also obstacles to be considered in the forms of harbor accommodation, water depth, and others.

All these considerations will be greatly subjected to the changes in social and economic circumstances, but, on the whole, it may be proper to put the maximum size of the bulk carrier in future as approximately 200,000 deadweight tons. (BB58)

14. He predicts further that:

- Oil will probably remain dominant fuel.
- The speed of large bulk carriers of the future will not be high (20 knots) and probably will be replaced by freight aircraft (passenger cruisers, 40 knots; ferries will be hovercraft, 80-90 knots).
- Automatic control for engine room, warning systems, positioning, pitch, etc., will be available.
- Less than 1/3 of present crew size will be sufficient for efficient and safe navigation. (BB58)

15. Increasing appearance of surface-effect vehicles and hydrofoils as ships of the future is anticipated. (BM43,95)

16. The widespread use of surface-effects ships for ocean transport will have extensive impact:

- Efficient and desirable passenger transportation systems for distances up to 100 miles.
- Applicatior to navy ships, particularly amphibious assault vehicles, greatly

Potential Impact

Predictions about transportation do not suggest many impacts on Navy personnel systems or Navy organization. A ship is not in most respects a system itself, but is a composite of systems which will affect personnel and organization (e.g., automation).

Nevertheless, the advancements predicted in relation to ships provide some basis for related suggestions here, particularly the prediction that crews 1/3 the size of current crews will be sufficient. This kind of prediction is certainly relevant to projection of Navy manpower requirements. However, it is a prediction that needs tempering by others—such as those involving future work patterns and predicting a work-week of 30-34 hours. Such a development might reduce crew size but require multiple crews.

Potential Impact

Changing work requirements in the transportation field may require that certain manpower skills in arrangements (recruitment,training, etc.) be revised, in relation to vehicles of land, sea, undersea, and space.

altering tactics and strategy.

- Development of high-speed ocean transit cargo system.
- Rebuilding of harbors and establishment of new ocean routes and parts.
- Development of fishing fleets using surface-effect vehicles.
- Effects on ocean shipping and air cargo shipping systems.
- Application to pleasure cruising vehicles.
- Diminished need for canals. (BM61)

17. Link predicts that by 1984, man will travel to a depth of 3,600 feet in pressurized underwater vehicles which will allow him to "emerge"to work (oil drilling, mining, fish culture, farming). There will be an array of engineering developments scattered on the ocean floor (tunnels, cables, derricks, etc.); and underwater habitats will provide living accommodations for work and leisure. In turn, it will be necessary to develop new methods of navigation in these depths.

Transportation and commerce will be enhanced by portable, inflatable submarine tankers run on nuclear power and not susceptible to problems of inclement weather and heavy seas.

All these developments will require worldwide international cooperation. (BB58)

Air Transport

18. The demand for air transportation will most certainly grow, a quest for higher speed constituting the major incentive.

Improvements in materials, construction methods, propulsion, reliability, methods of control and navigation, landing systems, etc., evolved for the development of supersonic aircraft; but these will be applied to all aircraft by 1984. The SST will stimulate improvement in the qualities of safety, regularity, flexibility of operation, and economy of equipment. This in turn, will enhance the continuous development of air transport. (BB58)

19. Civilian air transportation will be marked by international mobility, increased speed and safety, increased freight transport, agricultural and resource surveys, and decreasing costs.

Laminar flow, all-wing aircraft, variable sweepback, speed, vertical take off, automatic controls are all prime development areas. (BB58)

20. A recently developed innovation with implications for future air transportation is automated landing equipment.

In Army tests of this equipment, a helicopter occupied by two men, but not flown by them, achieved history's first fully automatic landing of a helicopter at a predetermined spot—Wallops Island, Virginia. Ultimately this equipment will be used in the flight of routine missions under poor visibility conditions. (BN270)

21. Another development, the routine use of reusable ballistic suborbital transports for military or commercial passenger and cargo transportation, would also affect air transportation.

- Increased mobility of military forces and material, proving very useful in limited war applications.
- A "smaller" world, at least for some affluent persons.
- Development of anti-ballistic rocket techniques by countries which wish to deny landing sites to these vehicles. (BM61)

22. In the area of air safety, it has been determined that the greatest cause of accidents is human error. Automatic pilot, improved air traffic control, automated repair, and simplification of communication systems are developments in which improvements will be sought.

Another cause of error is weather conditions. Forecasting techniques will be enhanced, but modification of unfavorable conditions (clear-air turbulence) will not be developed fully. High-speed flight will therefore not be as safe as we would like it to be.

Basic problems in many parts of the world arise from an insufficiency of trained men coupled with an insufficiency of funds. By 1984 there will exist the technical knowledge to produce complete air safety, yet accidents will still occur. (BB58)

23. An increasing general application of space technology, biomedical and

life-support developments, space materials and structures, space-related electronic developments, and systems management skills is anticipated. (BM43,95)

24. Phases in the development of space transportation are expected to proceed from unmanned probes, through manned exploration, to transportation systems. Kuhrt predicts that by 2000, the moon, Venus, and Mars will be in the transportation system network: Mercury, Jupiter, and Saturn will have been under manned exploration for 10 years; and manned exploration of trans-Saturn planets will have commenced, following unmanned scientific probes begun in 1987. Unmanned probes of trans-Plutonian space will begin about 1993. (BM43,95)

25. Projected Propulsion Systems of space transportation vehicles include:

- Nuclear systems replacing chemical rockets for primary propulsion.
- Chemical rockets will be retained for lesser applications.
- From nuclear fission to gaseous-core nuclear rockets, which will mark the beginning of true space transportation systems.
- Nuclear fusion systems will be in experimental development by 2000.
- Photon systems-rockets under study; testing of nuclear powered, gas laser photon directed propulsion.

Advances in satellite technology will center on the following areas:

- Communications
- Weather satellite - network of synchronous satellites worldwide, permitting accurate 2-week forecasts.
- Oceanography-satellites in conjunction with ocean data buoys.
- Navigation-greater precision of locations on earth (and space?)
- World resources survey-sensors detecting and differentiating crops; near surface minerals; water resources; forests; and works of man. These will be linked up with computer inventories by 2000.
- Surveillance-precision regarding total capability of nations, threat to privacy.

Research in the material sciences, biomedical sciences, system reliability, and systems management technology will enhance the space transportation program.

- Development of reusable space shuttle rocket plane.
- Development of permanent space station in orbit around earth.
- Development of space tugs to provide economical transportation between jets in earth orbit. (BM43,95)

26. Revision of gravitational theories, generating new modes of space travel, would have far-reaching impact on the future of space transportation, possibly leading to:

- Deeper understanding of the phenomenon of gravity.
- Revolutions in all terrestrial transportation modes.
- Exploitation of extra-terrestrial resources within the solar system, thus augmenting terrestrial resources.
- Eventually, manned interstellar or intergalactic expeditions. (BM61)

OTHER

1. Projections of the nature, extent, and impact of technological change over due next decades vary from forecaster to forecaster, but there is unanimous agreement that implications for future generations will be significant and farreaching.

2. Industry has barely tapped some of the new sciences: solid state physics, polymer chemistry, computer mathematics, etc. Great expectations are associated with synthesized materials, automated assembly machines, and computer oriented factories. The effects are to be analyzed by each type separately. (BB18)

3. Technology derived from the development of laser weapons, for example, will have a great many non-military applications by the end of the century.

- Extremely wide bandwidth communications
- Holography permitting transmission of three-dimensional images
- Transmission capability of touch, taste, and smell
- Development of minicomputer (significant advances in next decade)
- Greatly improved in computer memory storage density
- Anti-weapon devices (BM43,95)

4. Development of new plastics and metals for house construction will receive increasing attention, bringing costs down and bringing about new type of housing and atmosphere, thoroughly altering attitudes toward home life. (BB18)

5. A revision of gravitational theories in connection with new modes of space travel is seen also as precipitating a revolution in building and construction modes and trades. For example, giant structures, hundreds of storys high, or perhaps structures which would float over cities may be possible. (BM61)

6. A large number of new materials (e.g., metal "whicker" reinforced composites) for ultra-light construction (density of aluminum, strength and toughness of steel) will be commercially available for private use at competitive prices leading to:

- New architecture--open structures, long cantilevers
- Construction of large domes capable of covering stadiums or perhaps even entire cities

- Lower air transportation costs at higher speeds
- Retraining of construction workers, technicians, and architects
- Basic reorganization of the building industry, accompanying the reductions in the cost of housing and introduction of new techniques
- Improved weapons--e.g., personnel armor, rocket cases, armored helicopters, etc.
- Widespread alteration demands on traditional industries (e.g., timber) with subsequent drive to increase diversification, lower costs and develop new uses for their products. (BM61)

7. Currently, 93% of metal used in the world is steel (as of 1965), and there is no reason to expect that this proportion will change significantly by 1984 (Calder, for other opinions).

Total world output of steel by 1984 will be around 700 million tons, and the largest producers will be the USSR, the United States, Japan and India. Most underdeveloped countries will have small steelworks of their own capable of satisfying their simplest requirements. In the industrialized countries, the emphasis will be on more imaginative utilization of steel and higher quality products. (BB58)

8. Steel will not meet all of our needs in 1984 for a high-tensile, ductile material, as it loses much of its strength at high temperatures. Composite metals show promise. Other innovations in this area are predicted.

- New ceramic materials will be developed for heat resistant properties, but they will lack the strength and ductility of metals.
- New composite materials especially fibrous materials made in the form of thin, filaments will be produced. They are flexible, free from fatigue, have high strength-to-weight ratios, and could be glazed to give a protective finish. These made from high melting point oxides could provide heat insulation at high temperatures.
- Changes in building construction will require lighter, higher, more elegant materials, which will be derived mainly from high polymers, as they also provide thermal and sound insulation.

- Requirements of space travel will lead to development of new solid fuels.
- Electronics and optics (especially lasers) will require new conducting and insulating materials.
- Biological materials will also be artificially produced.

Basic research in physics and multidisciplinary efforts will be required to accomplish all this. (BB58)

9. Solutions to present metallurgical problem of developing materials for high operating temperatures may be found in one or a combination of the following.

- Strengthening by particles or filaments
- Engineering of equivalent biological materials
- Micro-engineering design
- Evolution of composite materials will develop manufacture by synthesis

Traditional employment patterns will be altered in the evolving metallurgical sciences, e.g., skilled operators will be replaced by program-controlled machine tools, work hours will shorten, and efforts will focus on maintenance of highly sophisticated equipment. (BB58)

10. Increased production of synthetic macromolecular products--plastics for packaging, building, etc.--is anticipated.

Synthetic textiles will become dominant fiber.

Use of synthetic rubbers with higher resistance and lower costs; Synthetics presently represent 1/2 rubber in use.

Development and increased use of synthetic textiles and rubbers with free land for agriculture. Production also of pure materials (vitamins and some carbohydrates) will occur, with anticipation for production of natural products and foods in great amounts. (BB58)

11. Investment in ocean technology will grow rapidly, and development of techniques farming and mining the ocean, establishing undersea colonies, and allocation of ocean resources will parallel progession of space activities.

Recreational technology will offer opportunities for engineering advances. Production of equipment and facilities for leisure will expand greatly, and novel transport for sea and mountain spots may become recreational activities themselves (use of motor scooter for sea races, instead of sea exploration, as it is now used). (BB232)

Potential Impact

Developments in ocean technology will doubtless involve the Navy in all of them. Those linked to material resources (e.g., minerals, undersea mining colonies) will involve a number of other national and international agencies, and be dependent upon major advances in a number of other fields concurrently. Others will advance according to discrete developments, but will probably involve the Navy in representing its own, maritime, or national interests, depending on the issues, in various international contexts.

12. Other developments in oceanography will include:

Coordinated system of orbiting weather satellites and instrumental ocean buoys to predict and control weather.

- Salt water conversion plants for production of fresh water, electric power, and magnesium
- Reconstruction of shoreline for recreation, fishing, mineral development (multiple uses)

There will be an increase in basic knowledge for how ocean and atmosphere interact drawing on new insights into the history of ocean basins. Computer models of relationships (hydrodynamic and thermodynamic) which can predict long-range weather and water conditions will be constructed.

Improvement of ocean drilling will facilitate understanding composition of earth, continental origins and history of the earth as a whole. (BB58)

13. Satellites will be used to monitor-

- Synchronous, worldwide weather data
- Ice distribution for navigation

- Food conditions and water distribution for algae
- (Infra-red sensors of) ocean currents and fish populations
- Disaster warning-fires, volcanoes, icebergs, solar eruptions
- Extra-terrestrial weather forecasts, astro-chemical and geophysical measurements
- Navigation and positioning of ground points. (BB58)

14. The technical problems of filling in gaps in our weather observation have been solved by the automatic satellite station. The question of cost remains, however, along with problems of internationalizing efforts and centralizing data collection.

Increased success of general long-range processes by use of computer simulation models has enhanced forecasting accuracy. But a theoryof "how" climatic processes work is needed in order to understand and accurately predict short-run and specific long-run events.

Such a theory should (1) establish mathematical theory of formation and motion of depressions and anticyclones; (2) study dynamics and thermodynamics of frontal systems and of quantitative prediction of precipitation (computer models); (3) study general circulation of atmosphere and climatic zones, especially those which give rise to transient climatics fluctuations; and (4) provide analysis of thunderstorm electricity to understand tropical hurricanes. (BB58)

15. The applications of meteorology will be expanded in the future and will impact on a broader range of activities:

(1) (General public) improved accuracy and availability of weather forecasts.

(2) (Aviation) increase in range and speed based on predictions, including rain and hail information, ozone, UV radiation, cosmic radiation, and artificial radiation, as well as conventional data.

(3) (Shipping) longer-range, with forecasts of gales, typhoons, and hurricanes enhancing speed and safety.

(4) (Agriculture) irrigation processes and crop development can be more effectively planned with aid of improved forecasts; pests and diseases which are weather-dependent may also be more clearly understood and controlled.

(5) Water resource development for hydro-electricity, human and agricultural consumption) prediction of reservoir dynamics, wind and solar radiation will enhance our prediction of energy production from these sources. (B358)

16. Future capability to provide regular and reliable weather forecasts 14 days in advance for areas as small as 100 sq. mi., would:

Improve economic conditions related to forecasts, thereby lowering insurance costs.

- Improve selection of periods for military operations.
- Complicate tourist and vacation business by assuring greater concentrations of traffic in periods of pleasant weather. (BM61)

17. Feasibility of limited weather-control, in the sense of predictably affecting regional weather at acceptable cost, is seen as precipitating a variety of events:

- International treaties and regulations concerning potential weather effects which cross national boundaries
- Great improvement in agricultural efficiency by creating rain on demand, avoidance of floods, and minimizing the number of clouds over farms during sunlight hours
- Certain areas of oceans becoming hurricane-dissipation areas
- Weather being used as a military or economic weapon
- Unexpected and perhaps detrimental effects on certain aspects of the local, regional, or planetary weather
- Disruption in ecological balance, leading to extinction of some plant and animal species
- Unpredictable psychoses in the population
- Great increase in number of civil suits alleging damage caused by weather manipulation
- Emergence of a new power elite: "the weather-makers" (BM61)

18. When weather can be produced to order, hydroelectric power may become competitive with thermonuclear power. World-wide weather engineering and control stations may be required. It may prove efficient to control weather from orbiting space stations which "bomb" the atmosphere with seeding chemicals.

An orbiting mirror, at high altitude, could direct sunlight to dark portions of the earth to control the night and illuminate areas for rescue operations.

Small manipulations may trigger relatively large planetary reactions; therefore complex analysis, observational networks, and computer predictive systems will be required when weather control is initiated on a larger scale. (BB16)

19. Simple weather prediction could have important economic consequences. President Johnson has stated that five-day accurate predictions could result in savings of 2-1/2 billion dollars to agriculture, 45 million dollars in the lumber industry, 100 million dollars in surface transportation, 75 million dollars in retail marketing, and 3 billion dollars in water resources management, in the United States alone. Weather manipulation will probably be relatively inexpensive; its economic effects will be tremendous. Certain areas of the country could be designated, for example, sun zones. Others could be set up for particular agricultural requirements: a rice zone, a cotton zone, etc. An orbiting mirror could produce heat where required for habitation or agriculture. (BB16)

20. Finally, will citizens of the future select their weather by referendum? Will there be lobbyists advocating the weather of their preference?

Daylight may be a purchasable commodity.

There may be a growing tendency to blame bad weather on the government. (BB16)

21. Another possible future innovation, development of new methods for modifying the environment, in general, would have a number of: implications for future societies:

- Increased technological and industrial growth, particularly in LDC's
- Shifting of population to new areas
- Improvement in leisure time utilizing and resort business. (BM61)

22. The problem of environmental pollution will continue to plague us. By 1980 the USA will probably have 120 million cars on the highways--one car for every 2-1/2 people. This could constitute a fatal dose of pollution in metropolitan areas.

Agricultural irrigation and fertilization (possibly because of their deleterious side-effects) will be cut below 1968 levels. This trend will begin to increase in the last half of this decade and will continue to increase in the 1980's. (BM94)

23. Development of efficient and economical means for disposal of solid waste products (or legislation which inhibits the use of products which do not decay) seems likely to produce the following effects:

- Improvement in ecology and appearance of the urban environment
- Reduction in cost of solid waste disposal
- Availability of new kinds of raw-material land fill and some structural materials
- Increased prices of commodities packaged in the new decaying containers
- Widespread reaction from certain industries to legislation prohibiting use of disposable, non-decaying products, such as plastic dishes, plastic and metal containers. (BM94)

24. Water pollution will present another challenge. The Cuyahoga River in Cleveland has been officially declared a fire hazard, and it is expected that Lake Erie will congeal within 25 years. (BB242)

25. A major industrial use of water is for cooling. When water is so used, it is unaltered and can be used by another plant downstream for the same purpose. However, there is a limit to the extent to which such practices can be carried out without penalty. This was demonstrated recently in Youngstown, Ohio, when it was found that so many industries were using and re-using the water of the Mahoning River, and that it became too hot to be used for cooling. (BB50)

26. To help alleviate these problems, it is expected that widespread use of self-contained dwelling units employing life-support systems that recycle water and air to provide independence from the external environment will occur, with a variety of repercussions:

- Further development of units for use in space travel or undersea use.

Potential Impact

Presumably, recycling life support systems may be sought eventually for ships at sea. Since such systems might be made self-contained for limited periods appropriate to port-to-port voyages, such systems might become feasible before similar systems for land units in congested areas.

- Reduction in degree of dependency of suburban residents on municipal government and its services and utilities
- Further fragmentation of society; the wealthy living in beautiful areas, poor in cities more uninhabitable
- Rejection by most people

(BM61)

27. The overall impact on society of advancing technology is viewed differently by various forecasters.

In Pentagon Capitalism, Seymour Melman predicts the development of an industrial management system within the federal government. With more than half the nation's scientists, engineers, and technicians working in military programs, he feels that research and development vital for civilian needs will suffer. In any society the supply of skilled people for such activity is limited.

He argues that in capitalist nations, military production is not required as a priority economic activity. (BP144)

Potential Impact

As referred to elsewhere, there is a high probability that competition will increase in society for certain types of scientific and technological expertise, with emphasis shifting from one specialty to another over time. The Navy is sure to be involved in the competition.

28. Fruchtbaum contends: "Technology may so change the nature of man and society that the very concept of choise and action will be totally altered and the possibility of open-ended options precluded."

He attacks Mesthene's spectre of an emerging technological elite, sophisticated in information handling and management techniques, running future governments, as described in Technological Change: Its Impact On Man and Society. (BP144)

29. And finally, a ray of hope from Alvin Toffler:

> It is obstinate nonsense to insist, in the face of all this, that the machines of tomorrow will turn us into robots, steal our individuality, eliminate cultural variety, etc. Because primitive mass production imposed certain uniformities, does not mean that super-industrial machines will do the same. The fact is that the entire thrust of the future carries away from standardization--away from uniform goods,

away from homogenized art, mass produced education and 'mass' culture. We have reached a dialectical turning point in the technological development of society. And technology, far from restricting our individuality, will multiply our choices--and our freedom--exponentially." (BB355)

PART III

Section 4

BIO-MEDICAL

BIO-MEDICAL

GENERAL

1. This Section bears obvious interrelationships with others, particularly certain predictions in the general area of technology. However, it appears to possess unique importance sufficient to warrant separate discussion. Its subsections are headed General, Medical Engineering, Genetics, Prolongation of Life, Behavior Manipulation, and Ethical Issues.

2. It is true that a good proportion of prediction in this field extends beyond the perspective of a decade -- probably more in this section than any other in the entire report. Nevertheless, many of the possibilities forecast herein are of such a nature as to demand very long thought and much discussion considering all the perspectives of mankind before the possibilities are allowed to proceed very far. Some of the possibilities that may lie before us involve steps which man may decide he does not want to take. Therefore, they need to be brought into consideration soon -- a decade from now may be too late.

3. We are now in the opening stages of the Biological Revolution, a 20th century revolution which may affect human life far more profoundly than the great mechanical revolution of the 19th century or the technological and social revolutions through which we are now passing.

4. Taylor says: The social and personal costs of adapting to this new knowledge will be terrifying and unacceptably high unless we make a major, conscious effort to regulate the pace and scope of development, instead of letting it control us. (BB349)

5. We are forced to the conclusion that society will have to control the pace of research; there will have to be a biological "safe deposit box" in which new techniques can be placed until society is ready for them.

To decide what is an optimum population level for human happiness and fulfillment is a task which the social sciences have not yet faced up to. But why single out the social sciences? Has anyone faced up to such a decision?

We have only temporary expedients as answers to the questions "How shall we contrive to exercise the formidable powers allotted to us by science with a minimum

sacrifice of decency and dignity? Upon what criteria shall we base choices that will commit the future?"

6. Moratitz distinguishes between advances which are probably within the scope of society to handle and those which create problems of a totally new order. In the first category he cites specification of sex of offspring and artificial placentas.

As examples of the second category, those changes creating fundamental problems, he would cite: (1) the development of techniques for dramatically raising intelligence, (2) drastic extension of life span, or even youthful vigor, causing tremendous social and economic repercussions, (3) The prospect of indefinite postponement of death, (4) The power to modify heredity. Economics cannot cope with (3) nor politics with (4).

Moratitz poses another crucial question: Is the political machine adequate and is the economic machine adequate to handle the problems raised by new technologies -- e.g., international implications, gap between haves and have-nots, legal definitions, unprecedented amount of change all leading to a kind of massive social disorientation and loss of social cohesion?

7. Our misuses of modern pharmaceuticals may dramatize the current failure

Potential Impact

No social institution or organization will escape either these changes or discussion of them long before they become reality. Some may begin to have applications before too many years; we shall single some of these out for separate discussion. The whole category of biomedical possibilities, however, will affect the Navy organizationally, and through its members past, present, and future. As noted here, the drug culture gives us some inkling of the potential nature and scope of uncontrolled experimentation. Suggestions to set up exploratory groups now to consider the potential effects of biomedical advances and how to handle them should be supported across a wide spectrum of society, for neither medical men nor physical scientists are competent to decide the most critical issues of ethics, politics, economics, and social philosophy. One aspect within the Navy's purview now is a shift of some degree from hardware research to social science research, including ethical issues.

of our society to instill a social conscience into its members, and give vivid insight into what the future may hold.

It seems quite certain that the new powers generated by advances in biology will have to be reserved for a mature and privileged group, to be rationed out only to those who can be relied upon not to misuse them. This is an anti-democratic process, and much to be regretted, but it seems the way the world is going. (BB349)

8. The time is ripe for scientific bodies (NAS) to set up committees to consider how to handle the problem of delegating responsibility in general and the biological revolution in particular. A primary difficulty in meeting these problems is that we have no clear agreement on what kind of world we want.

Professor Toynbee has described our situation as a failure of our emotional development to keep up with our intellectual development. But it is more to the point to say that our sociological knowledge has not yet kept up with knowledge in the physical sciences.

The basic answers lie for all to read in the works of wise men. Man is the measure; knowledge, without corrective charity, hath some nature of venom or malignity. It is the know-how for putting these principles into effect which is lacking. (BB349)

9. One of the main foundations of biology is the conception of life as a chemical

Potential Impact

Other predictive discussion related to some of these matters is included under Health, in the Social and Cultural Section.

mechanism, a manifestation of molecular architecture, and the evolutionary elaboration of this mechanism through random variation and natural selection.

The scientific community is not qualified to impose institutional remedies or moreal criteria for the problems of human opportunity.

10. Lederberg cites several predictions which highlight coming moral dilemmas:

> - The successful transplantation of vital organs: heart, liver limbs. The technical barriers will be overcome long before we can reach a moral consensus on the organization of the market for allocation of precious parts.
>
> - Artificial prosthetic organs...not yet being developed with the necessary vigor .....
>
> - In consequence of these, and probably other advances in, say, protein biochemistry, a sudden increase in the expectation, or prolongability, of life. With a wider range of technical resources will come a corresponding expansion of the scale of the useful cost of maintaining a given personality.....
>
> - More optimistically, the modification of the developing human brain through treatment of the fetus or infant.....
>
> - 'Clonal' reproduction, through nuclear transplantation. The prototype for this suggestion is the transplantation of a nucleus from an adult tissue cell back into an amphibian egg from which the natural nucleus has been removed.....The experiment has yet to be attempted in a mammal. Apart from its place in the narcissistic perpetuation of a given genotype, the technique would have an enormous impact on predetermination of sex; on the avoidance of hereditary abnormalities, as well as positive eugenics; on cultural acceleration through education within a clone; and on more far-reaching experiments on the reconstitution of the human genotype.

Lederberg feels we must assess the future with these predictions in mind. (BB58)

11. Through statistical research it has been shown conclusively that the rate of change in a person's life is linked to the state of his health. It has been established that 'alterations in life style' that require a great deal of adjustment and coping correlate with illness -- whether or not these changes are under the individual's own direct control, whether or not he sees them as undesirable. Furthermore, the higher degree of life change, the higher risk that subsequent illness will be severe. So strong is this evidence, that it is becoming possible, by studying life-change scores, actually to predict levels of illness in various populations. (BB355)

12. From a 1969 Delphi Survey of twenty experts, conducted by Rand, the following predictions of biomedical developments emerged:

1975 - Effective, simple, inexpensive fertility control.

- New organs, transplanted or prosthetic.

1980 - Central storage of medical data (in computer)

- Implanted artificial plastic and electronic organs.

1985 - Widely accepted use of non-narcotic drugs to effect personality change.

1990 - Creation of primitive artificial life.

Beyond 2000 - Genetic energy to control hereditary defects.

. Biochemical stimulation of regenerative process.

. Direct interaction between brain and computer.

. Chemical control of aging.

. Drugs to increase intelligence. (BM34)

13. It is believed that medical advances will not be diffuse and pragmatic, but that efforts will tend to concentrate in specialized "glamour" areas. (BB195)

14. The following may be included among the effects of new medical techniques:

- Increased population size
- Tendency to develop inferior race due to reversal of processes of natural selection
- Diversion of medical resources to rich and elderly. (BM61)

15. Development of a theoretical pharmacological discipline, permitting prior analytic determination of physiological effects of drugs, may serve to eliminate drug accidents (e.g., thalidomide), and lead to cures for almost all diseases. (BM61)

16. Large scale biochemical general immunization against bacterial and viral diseases is another goal of medical research, with the following potential effects:

Implicit in the eradication of viral diseases is the solution to the problem of back-contamination, the transmittal to the earth's biosphere of pathogenic organisms from alien planets.

Having accomplished general immunization, medical research staffs would be free to attack other medical problems not associated with bacteria and viruses such as transplantation of limbs and organs, genetic engineering, stimulation of the growth of new organs and limbs, and aging. (BB16)

17. It has been suggested that the orbital and lunar stations developed for space exploration might serve as sanatoria for stroke and heart patients, since the low gravity would probably prove beneficial to their recuperation. (BBI6)

18. The availability of implantable artificial hearts with power sources capable of lasting five years may change emphasis in medicine from repair to replacement. (BM6I)

19. Advanced techniques of opinion control, thought manipulation, and propaganda in combating crime, rebellious populations in time of civil upheaval, and in wartime would, in the opinion of a Delphi panel, be likely to heighten our understanding of behavioral processes. This should lead to efficient treatment of psychoses; with further insight, perhaps psychosis-provoking situations can be avoided. But without anxiety, will there be ambition? (BBI6)

20. Some authorities fear that the possible use of electrically-amplified or augmented communication between brains (controlled ESP) would lead to bizarre invasions of privacy. (BM6I)

21. In considering the implications of the creation of a primitive form of artificial life (at least in the form of self-replicating molecules), it has been postulated that continued research directed toward this end may identify the source of life on earth. Furthermore, this technology will undoubtedly add great expertise to genetic engineering, in which hereditary defects may be controlled through manipulation of genes. (BBI6)

MEDICAL ENGINEERING

1. The relatively new science of Medical Engineering will experience phenomenal growth over the next decades. Challenges of altering the biological nature and quality of life, not simply prolonging it, pose enormous ethical problems over and above the purely technical ones, and these must be resolved as technology advances.

2. Introduction of computers into the field of medicine has already had remarkable results, and is likely to cause even more startling future breakthroughs. Computers now store staggering amounts of medical data for instant access by doctors and nurses; they prepare prescriptions; detect mental and physical disorders; aid psychiatrists in therapy work; analyze data from medical examinations; and make diagnoses with greater accuracy than doctors. Much of the unforeseeable future in the realm of medicine may depend on the use of computers. (BM51,55)

3. We must try to anticipate the worse anomalies of biological powers; this is the first hope in developing institutional and technological antidotes. Some remedial possibilities are:

(1) Accelerated engineering development of artificial organs.

(2) Development of industrial methodology for synthesis of specific proteins with applications to homo-transplantation problems.

Potential Impact

The Navy and the other military Services in peacetime condition face medical problems and medical workloads that could be said to be excessively normal, in that the preponderance of members of the Navy are in good physical condition when they enter, and their own efforts and those of the Navy tend to keep them in good condition during their active service. Nevertheless, even in peacetime, various training activities are inherently dangerous to life and limb. Casualties will benefit, of course, from medical advances.

Potential Impact

It is in relation to battle casualties that the Navy and its sister Services will be able to benefit most from medical advances in rehabilitating its members who suffer wounds and diseases. Battle produces the most extreme range of injuries to the body, some without counterparts in civilian or peacetime circumstances. In every 20th Century war, military medical systems have been streamlined to provide swifter, more effective care, resulting in the recovery of higher proportions of wounded men.

(3) Vigorous eugenic programs in non-human species to produce "spare parts."

(4) Formal registration of all organ transplants.

The first three of these illustrate the gap between academic science and its economic application which private enterprise is discouraged from trying or is too inept to fill, and which calls for detailed social planning. We must face the issue of a definition of man. Eugenics and euphenics are the biological counterparts of education. (BB374)

4. The mechanics of heredity will be altered with the development of methods for transforming cells utilizing particles of RNA, which will replicate bioengineering research into feed-back control mechanisms, environmental control, product synthesis, prosthetics, and transplants will provide an understanding of the biological systems which will constitute the key to a new medicine.

Metabolic processes of plants could teach us much about devising artificial proteins, carbohydrates, energy cellulose, sugar, nucleic acids and amino acids. (BB58)

5. Yamada predicts future development of micro-organisms as food sources, antibiotics for cancer research, and enzymes to regulate metabolism. (BB58)

6. With respect to the problem of disease Still, a number of war casualties live out their lives in Veterans Hospitals. Any means of enhancing the rehabilitation of men damaged in defense of the nation, particularly those suffering permanent effects, will be welcomed and supported by the Navy.

Potential Impact

In early stages of development of replacement organs, when there are many applicants for few devices, it will be difficult to establish equitable priorities. Allocation of scarce benefits on the basis of ability to pay will become increasingly objectionable to American society.

Potential Impact

The Navy's outstanding medical centers will be participating in programs concerned with many of the developments predicted here and will doubtless be in the vanguard in some programs. On certain items, Navy participation will be selective.

control, it is anticipated that advances in the fields of biochemistry and pharmacology will provide the major solutions.

Practical use of general immunization against (e.g. interferon) which can protect against most bacterial and viral diseases will spell the end of the common cold and will increase productivity as a result of a reduction in sick days. (BM6l)

7. Development of a chemo-therapeutic cure for various types of cancer is seen as replacing surgery as the treatment of choice, thereby eliminating high hospitalization costs. (BM6l)

8. In addition to the great advances likely to be made in the field of artificial organs for the human body, a new study is emerging—the stimulation of natural regrowth of body parts that have been damaged or removed. A recently developed mathematical formula may provide the key, and is based on the theory that as an organ grows it releases growth inhibitors into the bloodstream, so that at the right time, the organ is inhibited from further growth. If the organ is removed by damage or surgery, the process might be restarted. In experiments, a rat's kidney compensated for the removal of its other kidney by increasing in size. The study may eventually result in some means of restraining the growth of a cancer. (BM5l,55)

9. Development of bio-chemistry processes which stimulate growth of new organs and limbs in humans will have economic consequences by enabling disabled persons to become more self-sufficient. It could also result in severe increases in medical costs and become another burden on the poor. (BM6l)

10. A capability to repair the central nervous system, including regeneration or repairs to individual neurons would result in decreased suffering through repair of congenital defects, stroke damage, certain types of polio, certain head injuries from accident or warfare, restoring functional capability but probably not memory or experience.

11. It would also lead to a reduction in the number of the insane. (BM6l)

12. Selective breeding of animals that are tissue-compatible with humans to provide a source of transplant organs could be the ultimate solution to the problem of transplant organs.

13. Development of implantable artificial heats with power sources capable of lasting five years will likewise lead to rise in new industries, technologies, and technicians devoted to production and installation of artificial organs. (BM61)

Potential Impact

Another deleterious possibility, should this situation ever materialize, might involve interest in large numbers of the dead, e.g., after catastrophes and battles.

14. Laboratory solution of the foreign-body rejection problem will greatly simplify organ transplants, and will also be of enormous importance in protection against viral diseases. With transplant procedures thus facilitated, storage of cadavers for "parts" and developing organ "parts" banks will follow. A deleterious effect of such developments might be a competition for organs, including black markets. (BM61)

15. Another Delphi panel contemplated the possibility of development of frozen-body storage to permit a form of time travel. The panel thought, that if such an unlikely development were ever to be realized, some of the following contingencies might ensue:

Development of stored human and intellectual resources, to be revitalized as needed.

Potential use of these techniques as a therapeutic maneuver for certain diseases.

Long-duration manned space travel made possible.

Maintenance of individuals with various diseases, until such time as the disease could be treated.

Use of these techniques to stretch food supplied by hibernating large numbers of people in time of famine.

Growth of a new"frozen-body" industry, perhaps resulting in an "overpopulation" of corpses; heavy social costs.

Criminals and "undesirables" being sent into the future. (BM61)

16. It is felt that development of a means for decreasing the time lapse between birth and maturity could lead to great increases in productivity, if emotional and intellectual maturity were also expedited.

However, it would also mean additional population growth, since procreation could begin at an earlier age. It would also shorten the best time of life.

Potential Impact

Radical impacts would probably accrue on the military services, as persons younger in chronological age developed capabilities of mature persons.

GENETICS

1. In considering population control, a Malthusian formulation is not adequate, for technology has added dimensions to the human problem that are unprecedented in the evolution of species. It is difficult to believe that a contraction of the human population will occur automatically. If we begin to poison ourselves with pollutants, we will take measures to reduce them. If we are afflicted by debilitative disease, we will subsidize biomedical science to find a cure. If our farms become inadequate, we will develop methods and build factories to produce synthetic proteins. If we invent thermonuclear devices capable of destroying all life, we will find social constraints on their use. No automatic biological principle will take over our destiny, for human intervention is possible, and in emergencies it can be rapid, massive, and effective. (BP416)

2. Harrison Brown observed that the postwar boom in babies resulted from increased birth rates in those groups that have had greatest economic and educational access to contraceptive techniques. This development makes it appear likely that given the perfect contraceptive, Western populations will not diasppear. Instead, we can expect far greater oscillations in birth rate than have been observed previously, the oscillations being reflections of fluctuations in overall economic and social well-being. (BB50)

3. By maintaining rigid control over aids to conception—in particular, artificial insemination, and rates of induced abortion—birth rates could be controlled with high precision, provided that fluctuations in natural rates of conception do not exceed the requests for aids to conception and for abortions. (BB50)

4. We can expect mortality rates to decrease in the future to the point at which death prior to and during the breeding period will have but small effect upon the reproductive rates of populations. (BB50)

5. If economic and social pressures can be stabilized to the point at which the natural net reproduction rate does not fluctuate upward or downward more than a few per cent from year to year, adequate control mechanisms are conceivable. (BB50)

6. The new methods of contraception which may become available during the course of the next decade may shorten the time lag between decreasing death rates and decreasing birth rates and thus make it possible for an area such as China to lower death rates and birth rates in unison, avoiding rapid population increases during the transition stage.

However, although the new techniques will help faster acceptance of contraception by eliminating inconveniences and great expense, they will not eliminate that component of resistance which arises from general social forces. Thus, even with drastically new contraceptive techniques available, it seems likely that a generation or more will be required for the methods to be generally accepted. (BB50)

7. Simple, cheap, and long-lasting birth control techniques will probably be available between 1975 and 1980, (BM94) and an immunizing agent that will prevent pregnancy may be developed. (BB242)

8. Development of economical mass-administered population control agents, for use by LDC's in technology, such as seeding of water could cause major changes in social values associated with child bearing, rearing, and sexual mores. (BM61)

9. Failure to gain control (of population growth) could result in wide-spread starvation, the Malthusian limit.

The incentive for the extension of life-span would diminish if the world overcrowds.

Overcrowding will produce unequaled problems in allocations of resources and in waste disposal. Some scientists have predicted that the earth will be doomed, eventually, by smog.

Overcrowding can lead to social pathology in which abnormal behavior patterns are developed. In experiments with rats, overcrowding led to abandonment of progeny, hypersexual and homosexual behavior, cannibalism, and other aberrations.

Achievement of effective fertility control will result in more rapid emergence of the underdeveloped nations.

Overcontrol—that is, a diminishing population level—could result in economic starvation--production without consumers. (BB16)

10. The ultimate goal of a population policy should be human welfare, and questions on values must be asked: Where should restraints be applied? To whom? The problem of reinforcing "dis-values" (discrimination,

Potential Impact

Various aspects of population control have been discussed in other Sections, as they relate to the Navy in the future.

inequality, false moralism) is very real; that is, true value goals must be pushed. A population policy should be devised which would seek "to make a contribution to the American dream above and beyond pressing demographic and environmental needs". In practical terms, a policy will have to be in the genuine interests of all citizens if it is to be followed.

The symbolic meaning of the policy should also be tied to broad goals. In foreign policy, the third world nations will be especially interested in the values to which the government subscribes for the people, and whether there will be a difference between home and foreign-population policies. (BB147)

11. Dr. Hafez has speculated that in 1980, it might be possible for a housewife to walk into a new kind of commissary, look down a row of packets not unlike flowerseed packages, and pick her baby by label. Each packet would contain a frozen one-day old embryo, and the label would tell the shopper what color of hair and eyes to expect as well as the probable size and IQ of the child. After making her selection, the lady could take the packet to her doctor and have the embryo implanted in herself, where it would grow for nine months, like a baby of her own.

Furthermore, it may be possible for the lady shopper to have her baby artificially inseminated using sperm contributed by a genetically-suited donor, perhaps a great man of the past.

As suggested by Dr. Sherman and other scientists, semen banks may be established in the future. Spermatozoa deposited in these

Potential Impact

Aspects of genetic control concerned with selection of parents, desired characteristics in offspring, preservation of certain characteristics in posterity and elimination of others, and replication of great men eugenically—all seem remote at this time; but no one knows whether efforts to realize them will be successful. Against the possibility that they will be successful, all important social institutions might well ponder what patterns of characteristics they would emphasize if their emphasis made any difference.

banks will be preserved by freezing. A husband, going away to war, might wish to deposit his seed. Possibilities for the use of such banks in eugenic programs are obvious. If these banks were shielded from nuclear radiation, destructive genetic mutations which might otherwise occur during a nuclear war would be avoided.

Dr. D. Petrucci of Bologna, Italy, and other scientists in the United States, have succeeded in fertilizing ripe ova in vitro. Reports have indicated that Dr. Petrucci's embryos grew for fifty-nine days, at which time he terminated the experiment. Perhaps this type of work will lead, someday, to the Huxlian picture of mechanized pregnancy, babies produced in glass wombs, freeing mothers from discomforts of natural pregnancy and providing the fetus with an ideal, optimum environment. (BBI6)

12. Development of techniques which would permit in vitro fertilization of a human ovum for implantation into surrogate mothers may lead to:

A multiplicity of desirable gene combinations,

Development of individuals with desired characteristics.

Fertilization of a human ovum in vitro with implantation into surrogate mothers may also lead to the emergence of a new profession of "hired incubators". (BM6I)

13. Human parthogenesis (an ovum stimulated into development of a full-term baby without being fertilized by sperm in host or natural mother) where the woman is the sole parent is another technique considered feasible

How much monolithic selection should be encouraged, and how much diversity? What characteristics, either singly or in various combinations, would the Navy regard as essential or desirable in future American citizens? What characteristics ought to be suppressed, or sublimated, or eliminated? What kinds of linkages should be sought between characteristics of the international context, national characteristics, and individual characteristics?

by the end of the century. Authorities feel that such a practice would result in:

- Reduction in variability of the species
- Ego-based psychoses in males
- Reversal in sex ratio, with ever-increasing numbers of females and eventually loss of sexual reproduction. (BM6l)

14. The ability to create a simulation of the placenta, making extra-uterine (fetal) development possible, is predicted for after the year 2000 and is expected to lead to changes in family structure, particularly in women's attitude toward "mothering," with pregnancy as now known becoming virtually non-existent. (BM6l)

15. Human cloning, in which the nucleus of an ovum is removed and replaced by a somatic cell, allowing development in a host mother of an identical twin of the person supplying the somatic cell, is projected as possible within the 1980's, leading to:

- Development of new animal breeding practices
- Creation of a super race; an effective way to preserve and distribute good genotypes
- Replication of essential or great mean, resulting in a kind of immortality. (BM6l)

Potential Impact

These changes portend radical impact on the role of women in society and in the potential relationships of women to the military establishment. In addition, radical effects on the role of the family in transmission of society's values to children. In turn, this hiatus will impact adversely on the pre-indoctrination of young entrants with value systems consistent with the Navy's, at least to some minimum degree.

16. Ernst Mayr predicts that genetic change will progress slowly—measured in generations. For several hundred years we may safely ignore the impact of genetic change.

In the matter of natural selection, it is not survival of the fittest, but mechanisms favoring genetic characteristics of organisms which have the most decendents in a given period. In high-density populations, conditions favor those who can best endure the worst conditions (less intelligent, less provident, less cooperative). (BM34)

17. Theodosius Dobzhansky: If we look at mankind as a species and ask what genetic changes will occur in the human population, nothing much will happen by 2000. After all, it is only slightly more than a generation. There are, of course, proposals, such as those of Huxley and Muller, to change the human population genetically. They plan to collect human semen and egg cells and to freeze them for later use. Efforts will be made to combine the eggs and sperm of highly intelligent people. So far this idea has been popular neither with most biologists nor with social scientists.

There should be considerable changes by 2000 in numbers of people. In the control of the population explosion, new techniques of contraception may have a considerable influence. If the population quantity is controlled, the question of population quality may become very important after the year 2000. (BP416)

18. Muller has commented on genetic progress: Modern civilization has instituted a negative feedback from cultural progress to genetic progress. This works by preventing the genetic isolation of small groups, by saving increasing

Potential Impact

Mayr cites a paradox of great potential concern to military institutions, which seek combinations of physical, intellectual, and moral quality and toughness.

numbers of the genetically defective, and by leading the better endowed to engage more sedulously than others in reproductive restraint. Yet the increasing complications, dangers, and opportunities of civilization call for democratic control, based on higher, more widespread intelligence and co-operative propensities.

The social devices and the individual persuasion regarding family size advocated by old-style eugenics are inadequate to meet this situation, except in extreme cases of specific defects. For the major problem, concerned with quantitative characters, the more effective method and that ultimately more acceptable psychologically is germinal choice.

Artificial insemination can, by becoming more eugenically oriented, lay a foundation for this reform. (BB374)

19. The ability to control the formation of new beings may be one of the most basic developments of the future. Recent discoveries about the nucleonic acids, the basic building blocks of life, have led to the belief that man may some day be able to treat genes in such a way that desired characteristics can be realized. With human prescriptions we could develop nearly any type of man desired — super-intelligent, highly taiented, better able to survive in severe climates, in rarified atmospheres of other planets, or underwater, etc. Other research indicates that tissue culture reproduction may also become possible. This would allow a man to have cells from his own body placed in storage so that a complete replica of himself could be grown from these cells after his death. (BM51,55)

20. Identifications of the codes will open new, vast engineering possibilities. Specific proteins may be manufactured by proper coding of cells in vitro. In all of man's history, he has had to rely on animals or plants for food. Protein synthesis through DNA controlled cellular processes will give man the opportunity to manufacture his food supply.

Genetic engineering may become important. As specific codes become known and as tools for manipulation become perfected, it may be possible to intervene in the cellular inheritance process and manipulate the instructions transmitted from one cell to another. Thus a new profession may be born. (BB16)

21. Control over the genetic process may make it possible to intervene in the heredity process and influence defects normally transmitted by this process. This type of genetic surgery may also be applied to "normal" characteristics so that specialized human beings might be produced to order.

Will we create all men equal or will we order special athletes for the "games"; research scientists with IQ's of 200 and diminutive bodies; and finally, the eternal model of youth for sex?

Starvation might be eliminated as a cause of death, since genetic processes could be used to manufacture proteins and genetic control of argicultural products could be expected to greatly increase conventional yields.

With the elimination of inherited disabilities, life expectancy would increase. Furthermore, aging itself may be found to be a genetic property.

Understanding of the genetic process may lead to the ability to control the antibody rejection process and thus permit the ready transplantation of foreign organs and limbs.

It has been theorized that each cell contains in it the data required to construct an entire human being. This is certainly true of a single ovum and sperm cell. Perhaps, someday, it may be possible to trigger a single cell into a process of replication so that a "clipping" from an individual would be sufficient to recreate the individual. This type of experiment has already been performed successfully with plants.

Genetic process may be employed to trigger the body's construction of new organs and limbs. (BB16)

22. If organisms can be grown in the pattern of previous genetic models, why couldn't memories be preprogrammed? Could we regrow Einsteins, complete with their experience and knowledge?

The ability to learn; almost certainly IQ; and what Jung called the "collective unconscious," the racial inheritance, can be influenced by genetic surgery.

Fertility, perhaps even aging itself, might be influenced with proper genetic intervention. (BB16)

23. In the field of human genetics, knowledge is growing at a staggering rate:

- New tests for disorders in human metabolism have been appearing currently at the rate of 2 or 3 each month.
- Reports have appeared on procedures for correcting a genetic defect in a mammalian cell.

- For the first time, man can directly intervene in his genetic future. It has been decided that the practice of genetic counseling poses more immediate and urgent ethical and social problems than does the more remote prospect of genetic engineering.

An attempt has been made to anticipate some of the questions raised by the prospect of widescale screening projects in this country. For example,

- Who should initiate a program?
- What rights to information will exist.
- How should genetic counselors be trained. (BB147)

24. Understanding of processes of differentiation and development, leading among other things to control regeneration and the ability to control certain phenotypes would precipitate great public debate over desirability of using genetic engineering techniques. (BM61)

Potential Impact

The possibility of actual genetic manipulation may be at least a quarter-century away. But discussion of its implications in advance will probably lead to more intense interest in those steps toward genetic "improvement" which are already feasible, some of which have been discussed inconclusively for years—for example, sterilization of criminals, and persons with certain diseases or defects. Discussion of such dilemmas may be forced to the point of decision in the next decade. Behavioral data developed by or for the Navy may become inputs to these discussions.

25. The feasibility (not necessarily acceptance) of chemical control over some human hereditary defects by modification of genes through molecular engineering is considered likely to produce:

- Growth of new discipline of genetic engineering and widespread genetic counseling services.
- Virtual elimination of genetically determined diseases and abnormalities, leading to improved race.
- Fashions in morphologic features, fads in faces, skin color, head shape, etc.
- Construction of specialized classes: menials, supermen, governors, and so on.

- Greater differentiation between socio-economic classes (and perhaps developed and less-developed nations) depending on who can afford it (natural selection replaced by affluent selection).

Projected as feasible by 1980, techniques by which sex of babies may be chosen with 90% certainty, would result in:

- Creation of legislation and incentives to guarantee a socially desirable ratio of males to females.
- Decrease in family size, since parents will no longer have to "keep trying for a boy"
- Increase in prostitution
- Fads for sexes (in absence of legislation fixing ratio) and major changes in sex roles. (BM61)

26. The possibility of developing raceless people through interbreeding (50 percent of world population) is seen as providing:

- The final solution to racism
- Improvement in health, genetic diversity, elimination of some diseases, and improvement of resistance to others
- Formation of new chauvinisms based on non-racial groups, such as professional affiliations or political blocs.

New eugenic techniques, in general, capable of producing a stronger, super-race are

Potential Impact

Changes in ratio of women to men in society may revise women's roles in society, and hence in the military establishment.

considered possible thru selective breeding of a long-lived race of human beings with an average life span of 90-100 years. (BM61)

PROLONGATION OF LIFE

1. Many scientists now believe that resistance to disease, which declines in advancing years, allowing the onset of fatal infection and illness, is partially a function of heredity, and therefore probably amenable to control by man. Hereditary material in the cells may, through damage or degeneration, generally stop directing these cells to repair or rebuild themselves. Better understanding of the nucleotides that govern life itself may eventually enable us to intervene genetically and augment the protective function in the body, perhaps adding 50 years to expected lifespans. (BM51,55)

2. Medical developments contributing to prolongation of life include:

- Advances in antibiotics
- Transplants
- Use of auxiliary machines to carry on work of the heart, lungs, and kidneys
- New techniques employing ultra-sound, lasers, and freezing to permit removal of tissue for diagnosis and treatment.

Chemical control of the human aging process, permitting extension of life span by 50 years, with commensurate increase in years of vigor, could present problems, such

Potential Impact

Prolongation of life, especially of the vigorous years, would pose a number of critical dilemmas. How much of life should be devoted to working life (paying heaviest taxes, contributions to Social Security, public and civic service, etc.) to warrant support by society during the remainder of life? Would the degree of vigor extended warrant comparable extension of career lengths in the Armed Forces? What would the Navy consider the optimum span for a career? What would be the trade-offs between bodies and minds which retained vigor for extended periods and cognitive orientations and perspectives which were formed decades earlier and require replacement, in the interests of the Navy?

as being used as reward for small groups ("High-ranking officials"), and creating sociological chaos, if developed too quickly,

3. A Delphi panel predicted that the development of new medical techniques to enable prolongation of life might have a variety of effects:

(1) Improvement in the efficiency of education and the level of wisdom in society, stemming from increased lifetime and education time.

(2) Increased life expectancy, combined with extra leisure, might provide extra emphasis toward education as a means of using leisure time.

(3) The major cause of death would become old age; senility might become more common.

(4) An increasingly aged population would force concomitant social changes: multiple careers, changes in marital structure, and many others.

(5) Slowing receptivity to change, as the median age in society increases, with further tensions between young and old. (BB16)

4. In considering the implications of extended lifespan to, say, 100 years, it must be assumed that an increase in life expectancy will also increase the number of years in which a man remains potentially useful and productive. Thus, a 100-year life span implies that

Potential Impact

One particular aspect of life extension should be given specific consideration in advance. The change might come very gradually, permitting concurrent adjustments at all age and other levels of society. On the other hand, it might come relatively swiftly, in one generation. The heaviest impact of delay, patience, temporizing, might fall on the generation behind the first generation to achieve life extension. Later periods would find social compromises pioneered, but the generation behind the first generation to be given, say, an extra fifty years of vigorous life would have to wait an unprecedented length of time to success to high place, to positions of power to inherit estates, to control family firms, etc.

increasing numbers of people beyond the age of 65 may wish to be employed. Leisure time would increase and expenditures for occupation of this time would also rise.

Our Social Security structure will require revision if economic minima are to be provided to the older citizens of our country.

The "senior citizen" bloc will have unique consumer demands such as: low speed automobiles, perhaps battery-powered for urban transportation; artificial organs; picture phones; mass-media entertainment; and household robots.

In spite of the presumed vitality of the older population, a maximum age of employment law might be enacted so that the younger people can work. If extensive social security measures were in effect, the young work force would thus be devoting part of its output to the support of the "senior citizen" group. (BB16)

Potential Impact

Various services may be appropriate for vigorous older persons to perform for the Navy, without overlong participation in the "mainline" of the Navy.

5. The possibility of guaranteed income and greater vitality among the elderly, as well as the present trend in birth rates and gerontological and medical progress, suggests the possibility of an "aged generation." (BM94)

Potential Impact

Navy budgets for support of the retired in income and facilities would increase substantially over years.

6. Norbert Wiener and others fear that life extension will keep in power bodies and minds which have become increasingly senile.

7. A shift in the median age may be accompanied by the formation of a political bloc of considerable power and significance and

special legislation may be enacted for the convenience of this group.. (BB16)

8. Advances will prolong the lives and productivity of many, but they may also overcrowd institutional facilities with disabled individuals whose death has been artificially delayed. One psychological hurdle for the first generation to achieve life extension (that is, before society is used to the situation and takes it for granted) will be boredom in various forms, one of which may be a conviction that according to the Biblical injunction, one has received one's allotment of time and has lived long enough.

9. One author pleads for a dignified and simple way to choose death. Older people who are senile and incapable of truly living on some minimum plane of satisfaction should be allowed to die. Doctors should not try to prolong their lives, nor should they in the case of a person about to die from a "hopeless and terrible disease."

If there is fear of younger people abusing such a situation, the parents could arrange to receive a reasonable annuity, calculated on buying power and not merely dollars, and let the children have the bulk of the estate when their children are young and when they need it most. (BB147)

BEHAVIOR MANIPULATION

1. In discussing the technological possibilities of behavioral manipulation, it is certainly reasonable to guess that control of mood in man may be possible by pharmacological and mechanical means in the next fifty years. Recent investigations have demonstrated many neural and chemical mechanisms necessary, for example, for initiating and maintaining sleep, and it is quite possible that investigations of these phenomena will progress rapidly. (BP416)

2. Studies have shown a relationship between aggressive acts or violence and biological factors such as brain damage, genetic abnormality, and hormone imbalance. Although this field is new, scientists are observing several interesting phenomena -- such as how aggressive behavior increases or decreases when subjects are given chemicals, and research has demonstrated that brain tumors, damage, etc., may be responsible for aberrant patterns in behavior. (BN528)

3. The following are methods of behavioral manipulation which, although possible of emergence within the next 30 years, are highly unlikely: (a) modification of genetic code (i.e., transformation or genetic recombination); (b) gene selection by controlled mating, as is currently carried on in experiments with animals; (c) nutritional influences; it is clear that certain relationships exist between diet and behavior; and (d) hormones; recent studies show that certain behavioral changes can be attributed to the effect of hormones, but relatively few studies have been done because other effects of hormones have held greater interest. (BP416)

4. One author asserts that "gene surgery, compulsory eugenics, chemical or electronic mind control, and the manufacturing of human duplication by 'cloning' are plausible." (BP28)

5. One author has advanced a theory dealing with the other side of aggressive behavior, in which he points out the relationship between what a person does -- his job, his personality, his life style -- and its attraction for violence. In this context, he characterizes Robert Kennedy as possibly a victim of such an assassin. This phenomenon

has given rise to a new discipline known as "victimology." The victim, it is said, seeks a life-style that courts trouble -- cab drivers, bank tellers, policemen. The author contends that the type of crime that occurs is often related to the bahavior that "provoked" it. Theft is often stimulated by the victim's negligence, swindles by his greed, or blackmail by his guilt. In other cases, one's suicidal wishes have provoked one's murder. Courses in victimology are being offered now at three United States universities: University of California, Northeastern University, and Boston University Law School. (BP207)

6. It is expected that established methods of behavior manipulation such as neurosurgical interventions (operations performed on the brain for relief of mental symptoms), surgery outside the brain (such as glandular removals), and environmental manipulations (e.g., the work of Pavlov or Skinner or hypnosis) will be refined and augmented by other techniques.

Quarton sees five possible scenarios in this area of behavior control:

(1) Extensive use justified as humanitarian to postpone death and relieve pain and anxiety.

(2) Extensive use justified as efficient to produce, for example, tireless and obedient soldiers.

Potential Impact

Behavior manipulation along certain lines is already well-established and socially approved. The raising of children entails a great deal of behavior modification and orientation. Religious bodies and training agencies seek constantly to reorient behavior. Certain medical practices involving disturbed persons are beyond objection. There would be little objection, probably, if some of these techniques were to be extended. Some of the "scenarios" suggested here by Quarton, for example, extend into controversial areas and some into areas that would be considered questionable by society as a whole at this time. Techniques intended to relieve suffering and improve individual adjustment to life will probably continue to receive approval. Techniques intended to revise behavior into forms considered more socially acceptable raise misgivings. For the spectre of misuse by unscrupulous persons adds pressure to fear of permitting any use of such techniques.

(3) Manipulation by premeditated social inefficiency and bureaucratic slippage.

(4) Puritanical avoidance of behavior control.

(5) Multiple parallel developments in which different segments of society use the techniques for their own ends.

Any use will raise serious issues of civil rights. (BM34)

7. Various authorities view development of new behavior manipulative techniques in general as possibly resulting in :

Strong government control to prevent abuses.

Great improvements in human capacities and preferences.

Control of the destructive element in man, reducing crime and the propensity to war.

Creation of a subservient class of individuals.

New tools for totalitarianism—endangering liberty, starving creativity, and stifling individuality. (BM61)

8. Experiments indicate that certain chemicals in the brain will, when implanted in another brain, transfer knowledge. Untrained rats have suddenly performed as if taught when injected with chemicals from the brains of trained rats, and scientists believe that memory storage, involving the DNA and RNA molecules, is the same in animals and humans. These chemicals, perhaps in pill form, may eventually have

Potential Impact

Research into the roots of war has never yet produced satisfactory results. The drives in man which are termed aggressive and warlike seem linked to drives termed ambition, vigor, and positive leadership. How these drives come to be manifested in constructive or destructive ways is not known. The capability and willingness to defend society must overmatch the capability and willingness to destroy society (or selected targets), otherwise, predators will always succeed. Categorizing military establishments in America as aggressive and warmongering is not only simplistic and inaccurate; it obfuscates attempts to understand such orientations with definition. Proposals to modify the behavior of soldiers and sailors to make them, on the one hand, tireless, obedient automations, or on the other, insensitive fanatical killers, will be examined by the Navy with great caution and, in our society as constituted so far, with distaste. But it will also follow assiduously the potential capability of any other nation or social entity to employ similar procedures against American forces.

highly beneficial uses. Electrical and chemical stimulation of brain cells has also shown remarkable results in calming nervous monkeys, changing basic needs of rats, and even stopping a bull in midcharge. These early efforts may lead to a totally new understanding of the human brain, and new means of correcting mental disorders. (BM51,55)

Potential Impact

9. Non-genetic manipulation of development during embryonic stage to increase the size, complexity, and intelligence of the human race. (BM61)

The Navy will follow with interest any practice which promises to increase the capabilities of the individual.

Research in personality-control drugs may lead to a new psycho-technology by which predetermined moods, responses, perhaps even intelligence levels, may be obtained through the use of drugs. (BB16)

10. The use of drugs to raise the level of intelligence (other than by means of a dietary supplement and not in the sense of only temporarily raising the level of apperception) is viewed by a Delphi panel as having potentially detrimental implications:

- Increased strain between old and young.
- Differential benefit to upper-income groups.
- Creation of a super-race which rules the world.
- Restriction of use to special groups, e.g., military applications. (BM61)

11. Many drugs affecting the central nervous system are now believed to act by influencing the availability of norepinephrine. This system is increasingly considered to be important in the mechanisms that determine mood.

Although there have been many attempts recently to demonstrate that RNA and protein synthesis are essential for learning and memory, much more research needs to be done. Some drugs are known to enhance slightly the efficiency of certain types of learning in animals. Investigations in this area are certain to continue, but the outcome is not predictable at present.

Drugs that expand consciousness, such as LSD, produce a subjective experience that combines an intensification of sensation with some confusion and heightened emotions, including elation and fear. The most dramatic aspect of these psychedelic drugs is that they have escaped the control of the scientific community and are distributed and used by sub-cultures within our society. It is not possible to predict the future of these drugs because new scientific discoveries can radically alter utilization parterns, and because use of drugs for "kicks" is complicated by other very complex social phenomena. (BP416)

Potential Impact

The Navy is striving to cope with the problem of drug abuse among the minority of its members who use and abuse drugs. We do not comment here on such current programs. However, Navy interest in drug-control programs will extend and increase indefinitely; for, as documented in this section, there is widespread interest in increasing drug usage in the future for various "legitimate" purposes. Accordingly, dangers will continue, and possibly increase, that drugs in greater volume and potency may again "escape the control of the scientific community."

12. LSD, or its equivalents, may offer sensitive tools for the exploration of human awareness and the changing of early imprints that today separate man from man and man from the world he inhabits. The point here, according to Chicago psychiatrist Dr. Marvin Ziporyn, is that the consciousness-expanding drugs may offer a way out of some of the problems that plague our current society. With LSD one has no greater vision of the universe than before. It no more expands consciousness than an X-ray expands lungs when viewed on a screen. All that is achieved is a better look.

Another interesting aspect of the psychedelics is what several research psychologists have termed the similarity between the effects created by these chemicals and the sort of consciousness identified with creativity. A rather far-removed speculation is the fascinating possibility that in future years the psychedelic drugs may make accessible to the average man levels of consciousness and perception previously restricted to the artist. (BM55)

13. While hallucinogenic drugs are not apparently, in the strictest sense, habit-forming, there can be psychological addiction.

The insight gained in psychodrug research could result in an order-of-magnitude increase in the number of cases amenable to chemical therapy.

Possible effects of the availability of cheap non-narcotic drugs (other than alcohol) for purposes of producing specific changes in personality character include:

Improvement in learning ability.

New therapies for the mentally disturbed (easing health load).

A decrease in crime rates.

Creation of group of "Jekyll & Hydes" in society.

Uses which seek to socialize and conventionalize the young.

Creation of special emotion drugs for soldiers; a drug-sustained Spartan military class.

A quarter to half the population in widespread hedonism.

Elimination of culturally distinct minorities. (BM61)

14. The impacts of another technique, controlling behavior of some people in society by radio stimulation of the brain, are considered likely to cover a similarly wide range:

Use in medicine as a form of sedation.

Stimulation of socially useful responses, e.g., a desire to work.

A substitute for penal institutions.

A decisive tool for control of abnormal (including criminal) behavior.

Development of protective and jamming systems. (BM61)

15. Experiments conduct by McConnell of Michigan, Jacobsen of UCLA, and many others indicate that memory may somehow be stored in molecules of ribonucleic acid (RNA). While widely contested, the possibility exists that in the future, memory pills, even intelligence pills, may become available. (BB16)

16. Finally, could pill production for social use become big business? The ready availability of anxiety-reducing drugs may make leisure a pleasurable, perhaps hedo-continuum of escape. Persons addicted to the new drugs, either physiologically or psychologically, will be withdrawn from the work force. If the movement becomes widespread, the nondrug workers (perhaps softened to their task by other drugs) may have to produce for the idle. (BB16)

Potential Impact

In speculating about far-fetched possibilities of affecting large segments of the population in debilitating ways, the Navy will include speculation about ways in which to forestall the rendering of large segments of our population (especially our armed forces) passive or otherwise debilitated, especially in times of crisis, and especially when it is suspected that such activities may be undertaken in the interests of a hostile nation (or even in the interests of a would-be domestic totalitarian).

17. Availability of LSD-like drugs to heighten the perception and the learning speed of retardates would very likely result in a reduction in the number of institutionalized retardates, and could help teachers who would administer drugs as a curriculum aid. (BM61)

18. Specific knowledge of how to stimulate cognitive growth to maximize ability of preschool children will enable planners to modify the educational systems (such as starting school at the age of 3), and will result in children developing intellectual abilities more rapidly (e.g., reaching present intellectual age of 20 at chronological age of 12). (BM61)

19. Development of techniques to permit education by direct information recording on the brain would permit shortening of the educational process and initiation of independent thinking at an early age. It might permit elimination of "factual" teaching, since this type of data would be stored more effectively in machines. It might also permit brain-washing of whole generations of youth to certain value systems or political styles. (BM61)

20. The mapping of the functions of the brain will lead to an understanding of brain mechanisms; this in turn may lead to more efficient, adaptive computers and programs which function in a 'reasoning' manner.

Machines which multiply human energy, force and dexterity, and respond to thought rather than switch-throwing may be possible, permitting extension of the environments in which humans may function. For example, a remote controlled Mars surface robot may be possible which presents 3 D-TV images to the operator on earth, and responds to the body motions and amplified thought commands of the earth-bound explorer. (BB16)

Potential Impact

21. Gordon and Helmer's Delphi panels pondered many aspects of robot mechanisms and man-machine symbiosis, enabling man to extend his intelligence by direct electromechanical interaction between his brain and a computing machine. These were among the potential implications foreseen by the panel: the elimination of factual education, since this data could be stored; these developments could also result in the creation of robots which would be used to decrease human risk, as in war. (BM61)

As noted elsewhere, the prospects of developing robots for battle purposes seems too far fetched for discussion in relation to the purpose of this project.

22. The possibility of electrically amplified or augmented communication between brains (controlled ESP) is foreseen as likely to precipitate:

- New modes of scientific collaboration.
- New approaches to situations which demand absolute honesty,

such as criminal justice, and diplomacy.

- Replacement of normal communication modes (telephone and telegraph), particularly for military applications.
- Thought interference might become a form of aggression; thought shielding would become a social necessity.
- There would be great difficulty in establishing "priority," in the original authorship, for example, or a concept or idea. (BM61)

23. The feasibility of safely reducing the amount of slow-wave sleep required would also have a number of repercussions:

- Large increases in human productivity.
- Increased requirement for leisure time activities.
- Widespread practice of multiple simultaneous careers.
- Rejection by society, if sleep turns out to be a highly desirable use of leisure time. (BM61)

24. Relatively widespread use of brain surgery or psychochemicals for the modification of the behavior of criminals in the future may lead to improving social responsiveness and competence of criminals; great decrease in the crime rate; reduced recidivism by criminals; closing of penal institutions. (BM61)

25. The brain's capacity for sending and receiving signals through means other than the known senses has been indicated in a number of experiments. In one, totally deaf subjects experienced pure tone hearing, speech hearing, and music hearing when low frequency RF energy was beamed at them. Particularly gifted deaf subjects have even experienced thought transfer over distances approaching 200 miles, though the carrier system, its modulation, and the brain channel used are unknown. In another experiment,

Potential Impact

Many of these predictions are extremely interesting and provacative. Insofar as they will remain far-removed as actual possibilities for a longtime, it cannot be foreseen that they would have impacts on the Navy or Navy people different from impacts on American society in general. As their possibilities become probabilities, the Navy will be examining their implications in due time.

a doctor successfully transmitted Morse code by controlled brain waves alone. The phenomenon, capable of activating a computer, demonstrated the sending ability of the brain. ESP, the subject of extensive research, is unlikely to become a controlled science in this century, but its potential is remarkable. (BM51,55)

ETHICAL ISSUES

1. The more we contemplate some of the bio-medical changes predicted for the future and speculate about their nature and unprecedented dimensions in relation to familiar aspects of man's mind, spirit, emotions, and soul, the more acute and inscrutable some of the inevitable ethical dilemmas seem likely to be.

2. One writer has discussed the biological possibilities in the next 10,000 years and poses the following sensible questions:

(1) What performances are within capacities of most people being born at the present time?

(2) What performances, considered desirable, are within the capacity of a small minority only?

(3) What evolutionary trends may be expected in the absence of conscious control?

(4) What trends may be expected if they are consciously controlled?

(5) How far must answers to (3.) and (4.) be modified for human beings living on other planets, satellites, asteroids, or artificial vehicles?

Within 10,000 years, Wolstenholme sees a real prospect of our species dividing into two or more branches through specialization for life on different stars or for development of different human capacities. (BB374)

3. He foresees the appearance, in 500,000 years, of a new mammalian species.

4. In discussion of the ethical considerations facing biological scientists, Szent-Györgyi states that we have reached the stage where we cannot understand the things we discover.

Ethical considerations also concern other authors:

> Crick - I think that in time the facts of science are going to make us become less Christian. There is eventually bound to be a conflict of values.
>
> Lederberg - No one who knows the children of accepted geniuses would suppose that the population would greatly benefit by there being several hundred of them. (BB374)

5. In a thought-provoking article about the ethical issues that arise in the treatment of patients with diseases requiring sophisticated and costly machines, one writer poses several important questions. The examples given deal with use of the artificial-kidney machines:

(1) The selection of patients; how does one do it?

(2) Who has the powers and legal responsibility for making the decision?

(3) How do those not chosen accept death gracefully?

(4) Who has the responsibility, and under what circumstances, to turn off the machine or refuse its use?

(5) What happens to doctors and hospital administrators who make these decisions? (BN267)

6. Chemical control of the human aging process, perhaps permitting extension of the life span by 50 years, with commensurate increase in years of vigor, is considered likely to precipitate changes in values regarding death and punishment. (BM61)

7. It is probable that technology permitting laboratory creation of a primitive form of artificial life (at least, in the form of self-replicating molecules), would deal a further blow to religious fundamentalism, and will contribute to the view that science is irreligious. (BM61)

8. Creation of means for decreasing the time between birth and maturity, bringing physical and perhaps intellectual maturity at earlier ages, might lead to radical changes in the whole fabric of social interrelationships, including the education process, family structure, political activity, and other sensitive areas. (BM61)

9. Development of techniques permitting electrically amplified or augmented communication between brains (controlled ESP) is considered by one writer likely to create unforeseen strains in international politics, business, and family relationships. (BM61)

10. The same questions occur as one contemplates predictions of genetic

manipulation, personality and thought manipulation, and man-machine symbiosis:

> Who will choose the models? What values will he use as criteria?
>
> Who will choose the defects to be eliminated?
>
> Who will select the parents for genetic replication?
>
> Who will develop the programs of thought to be implanted?
>
> Who will write the educational programs?
>
> Whose politics will be programmed?
>
> What consequences are desired? (BB16)

11. With increased understanding of genetic endowments, Medawar argues, "marriage between two people who carry the same unfavorable recessive genes should be discouraged." (BB242)

12. In discussing population control,

> We begin with individuals because it has already been contended that, in the ranking of values, individual freedom of choice has been accorded an international primacy; and it is individuals who procreate. What are the rights and obligations of individuals with regard to procreation? (BM22)

13. In the area of family planning and population limitarion, a number of national and international declarations have served to give primacy to individual freedom. The Declaration of the 1968 United Nations International Conference on Human Rights is representative: '. . . couples have a basic human right to decide freely and responsibly on the number and spacing of their children and a right to adequate education and information in this respect.' While this primacy has been challenged, it retains its position, serving as the ethical foundation of both domestic and foreign family planning and population policies. Accordingly, it will be argued here that the burden of proof on proposals to limit freedom of choice (whether on the grounds of justice or security/survival) rests with those who make the proposals, but that this burden can, under specified conditions, be discharged if it can be shown that a limitation of freedom of choice in the name of justice or security/survival would tend to increase the general balance of good over

evil. This is only to say that, while the present international rank order of preference gives individual freedom the primary place, it is possible to imagine circumstances which would require a revision of the ranking. (BM22)

14. In an ethical discussion of the issues of population control, one author has advanced the following "General Moral Rules:"

> Individuals have the right to freedom of procreative choice; they have the obligation to respect the freedom of others and the requirements of the common good.
>
> Governments have the right to take those steps necessary to secure a maximization of freedom, justice and security/survival; they have the obligation to act in such a way that freedom and justice are protecied and security/survival enhanced.
>
> Organizations have the right to act as they see fit providing thai they respect the rights of individual and governments; they have the obligation to respect those rights. (BM22)

15. Population control is an immediate problem, with mounting pressures behind it for very good reasons, as we have discussed in other sections. Yet, the ageless cycle of generation is deeply rooted in many cultures, and perhaps in the human psyche. We do not know what the consequences will be of trifling with it. As the foregoing passages attest, there are universal ethical mores concerning it, so that we readily see that the prob em will not be resolved easily, or soon, or by adoption of a stance of moral superiority.

Yet, this may come to be regarded as a problem of relative ethical simplicity, compared to the ethical dilemmas involved in organ transplantation, chemical manipulation or personality, genetic manipulation, prolongation of life, and other biomedical possibilities cited earlier.

16. Scientists and doctors, theologians and legislators, and professionals from a number of other doctrines, pondering innovations occurring or expected in the life sciences, are being moved to intense interest in the moral dilemmas that will accompany certain innovations. Of particular concern are developments to transplant hearts;

drugs to alter emotions and behavior; the creation of test-tube babies; and the manipulation of genes to "improve" the human race; and even more bizarre possibilities. Some of the traditional assumptions that underlie not only biology and medicine, but all science and technology, are under attack. It was noted in March. 1971, that Congress, research institutes, universities, and individual scientists are organizing ethical questions, debates, courses, and even separate institutes concerned with probing the ethics of approaching dilemmas. (BN289)

17. In October, 1971, a group of 21 eminent scholars and professionals signed a statement urging that wisdom and ethics -- and not just knowledge -- become determining factors in conducting technological advances affecting human life. All were participants in a symposium sponsored by the Joseph P. Kennedy Foundation. One speaker said that ethical dimensions of technology were being largely ignored by both scientific and medical institutions. (BN310)

Herman Kahn offered a startling conclusion:

> Now this is very hard for me to say ... but the knowledge and technology that are now becoming available are very hard for society to absorb, so we may well need an Index of Forbidden Knowledge ... A good deal of genetic engineering looks to me as though one might be better off without it ... (BN581)